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**Communications, Navigation, and Networking reConfigurable Testbed (CoNNeCT) Project**
National Aeronautics and Space Administration
John H. Glenn Research Center at Lewis Field, OH 44135

# CoNNeCT PROJECT

# SYSTEMS ENGINEERING MANAGEMENT PLAN (SEMP)

| AUTHORIZED by CM when under FORMAL Configuration Control | |
|---|---|
| **Date** | **Signature** |
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## PREFACE

National Aeronautics and Space Administration (NASA) is developing an on-orbit, adaptable, Software Defined Radios (SDR)/Space Telecommunications Radio System (STRS)-based testbed facility to conduct a suite of experiments to advance technologies, reduce risk and enable future mission capabilities on the International Space Station (ISS). The Communications, Navigation, and Networking reConfigurable Testbed (CoNNeCT) Project will provide NASA, industry, other Government agencies, and academic partners the opportunity to develop and field communications, navigation, and networking technologies in the laboratory and space environment based on reconfigurable, software defined radio platforms and the STRS Architecture. The CoNNeCT Payload Operations Nomenclature is "SCAN Testbed" and this nomenclature will be used in all ISS integration, safety, verification, and operations documentation. Also included are the required support efforts for Mission Integration and Operations, consisting of a ground system and the Glenn Telescience Support Center (GRC TSC). This document has been prepared in accordance with NASA Glenn's Configuration Management Procedural Requirements GLPR 8040.1 and applies to those CoNNeCT configuration management activities performed at NASA's Glenn Research Center (GRC). This document is consistent with the requirements of SSP 41170, Configuration Management Requirements, International Space Station, and Space Assurance and Requirements Guideline (SARG).

# DOCUMENT HISTORY LOG

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# 1.0 1.0 INTRODUCTION

## 1.1 Purpose

This Systems Engineering Management Plan (SEMP) describes the technical and integration approaches accepted for the design, development, test, and evaluation (DDT&E), deployment and initial on orbit check-out for Phase I of the Communications, Navigation, and Networking re-Configurable Testbed (CoNNeCT) Project. Specifically, Phase I covered the development of the flight and ground systems, system integration, launch, on-orbit checkout and commissioning of the flight system. This SEMP does not include Phase II in which Mission Operations and experiments will be further defined and conducted on-orbit. This SEMP will be used to organize work and to accomplish the project goals within cost and schedule requirements levied on the CoNNeCT project by the Space Operations Mission Directorate (SOMD) at NASA HQ. The SOMD is the stakeholder for the CoNNeCT Project.

The GRC leads the design, development and integration of the CoNNeCT system that is to provide for the advancement of Software Defined Radios (SDR) and the Space Telecommunications Radio System (STRS) standard and demonstration of space communication links critical to future NASA missions. The GRC will use a combination of civil servants, support service contractors, and external partners at JPL, GSFC, JSC, Harris Corporation and General Dynamics (GD) to develop the CoNNeCT system.

The CoNNeCT Project is managed out of the Space Flight Systems Directorate (SFSD) at the GRC.

This SEMP further defines interfaces, roles, and responsibilities between the CoNNeCT Project and other organizations, and within the CoNNeCT Project team including external partners at JPL, GSFC, JSC, Harris, and GD. This plan also establishes the structure and processes to provide management with necessary information for making systems engineering decisions.

## 1.2 Scope

This document applies only to technical management and integration activities related to the CoNNeCT Project including its components and Ground Support Equipment (GSE). This version of the document is being prepared in preparation for the Preliminary Design Review (PDR) of the CoNNeCT Project development activities at the GRC with external partner participation. The external partners are developing the SDR and other subsystems and will conduct their own project reviews with insight provided by the GRC CoNNeCT Project team. The project is nearing the completion of the preliminary design phase as the last review in the formulation phase. During the PDR it will be demonstrated that the preliminary design meets all system requirements with acceptable risk and within the cost and schedule constraints, and the basis for proceeding with detailed design will be established.

The SEMP may be updated and approved by the Engineering Director as necessary before each major review and other milestones to reflect the evolution in planning for the CoNNeCT Project's successive life cycle phases and for any changes in management strategy and processes that necessitate a change in systems engineering management processes.

Changes to the document will be made in accordance with the CoNNeCT Change Control Process outlined in the CoNNeCT Configuration Data Management Plan, GRC-CONN-PLAN-0002.

## 1.3 Overview

This SEMP follows the structure as specified in NPR 7123.1 Appendix C. It contains the following major sections:

**Section 1: Purpose and Scope**
This section describes the purpose of the CoNNeCT SEMP, scope of the document (time frame of the document and organization of project technical implementation, and content of the CoNNeCT SEMP.

**Section 2: Applicable Documents and Designated Governing Authority (DGA)**
This section lists the documents applicable to SEMP implementation and describes major standards and procedures that the CoNNeCT Project needs to follow. This section describes the DGA for the CoNNeCT Project.

**Section 3: Technical Summary**
This section contains a technical summary of the CoNNeCT Project, CoNNeCT subsystem structure, i.e., structure of the end product, enabling products, and their relationships, including Work Breakdown Structure (WBS) organization, and explanation of how the product will be integrated analytically and physically. This section also describes CoNNeCT Project planning efforts (life cycle, major technical milestones), and boundaries of technical effort (what is controlled by the CoNNeCT and what is not controlled by the project but can influence the project schedule, cost, etc.).

**Section 4: Technical Effort Integration**
This section addresses a description of the organizing structure for the technical teams assigned to this technical effort and includes how the teams will be staffed and managed. It also contains a description of how the technical effort of in-house and external contractors is to be integrated for the CoNNeCT Project.

**Section 5: Common Technical Processes Implementation**
This section describes each of the 17 common technical processes in a separate subsection that contains the plan for performing the required process activities for the CoNNeCT Project.

**Section 6: Technology Insertion**
This section usually contains a description of the approach and methods for identifying key technologies and their associated risks and criteria for assessing and inserting technologies. The CoNNeCT Project implementation consists of new technologies associated with the software defined radios.

**Section 7: Additional Systems Engineering Functions and Activities**
This section contains a description of system safety approach adopted for the CoNNeCT Project.

It contains reference to specialty engineering disciplines (risk assessment, logistics, reliability, maintainability, quality, operability, and supportability) applicable to CoNNeCT Project are addressed in this section.

This section also contains a description of the methods (such as integrated computer-aided tool sets, integrated work product databases, and technical management information systems) that will be used to support technical effort integration.

**Section 8: Integration with the Project Plan and Technical Resource Allocation**
This section addresses the relationships of this plan and CoNNeCT Project management plan, how technical requirements will be integrated with the project plan to determinate the allocation of resources, including cost schedule, and personnel, and how changes to the allocations will be coordinated.

**Section 9: Waivers**
This section contains (or will contain) all CoNNeCT approved waivers to the Center Director's Systems Engineering NPR Implementation Plan requirement for the standard SEMP.

**Appendices:**

Appendix A contains the entrance and success criteria from each of the reviews specified by NPR 7123.1 and the project's expectations for meeting those requirements.

Appendix B is the Acronyms listing.

# 2.0 APPLICABLE DOCUMENTS

## 2.1 Applicable Documents

The documents in this paragraph are applicable to the extent specified herein.

| | |
|---|---|
| GRC-CONN-PLAN-0004 | CoNNeCT Project Plan |
| NPR 7120.5 | Program and Project Management Processes and Requirements |
| NPR 7123.1 | NASA Systems Engineering Processes and Requirements |
| NPR 7150.2 | NASA Software Engineering Requirements |

## 2.2 Referenced Documents

The following documents contain supplemental information to guide the user in the application of this document.

| | |
|---|---|
| GRC-CONN-ICD-0067 | CoNNeCT to TSC ICD |
| GRC-CONN-ICD-0069 | RF ICD with TDRSS and Ground Network |
| GRC-CONN-OPS-0026 | Operational Concept Document |
| GRC-CONN-PLAN-0001 | Software Configuration Management Plan |
| GRC-CONN-PLAN-0002 | Configuration Data Management Plan |
| GRC-CONN-PLAN-006 | CoNNeCT Product Assurance Plan |
| GRC-CONN-PLAN-0007 | Risk Management Plan |
| GRC-CONN-PLAN-0012 | CoNNeCT Verification and Validation Plan |
| GRC-CONN-REQ-0019 | Level 1 Requirements Document |
| GRC-CONN-REQ-0031 | CoNNeCT Science and Technology Requirements Document |
| GRC-CONN-REQ-0035 | Flight System Requirements Document |
| GRC-CONN-REQ-0036 | Ground System Requirements Document |
| GRC-CONN-SRD-0013. | CoNNeCT System Requirements Document (SRD) |
| GLPR 7123.35 | Glenn Level Procedure Technical Assessment |

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| GLPR 7123.36 | Glenn Level Procedure Engineering Review Boards |
| GLPR 8040.1 | Glenn Procedural Requirements for Configuration Management |
| SSP 53112 | ExPRESS Logistics Carrier (ELC) to CoNNeCT Interface Control Document (ICD) |
| JHX-2009142 | Launch Vehicle (HTV) to CoNNeCT ICD |

## 2.3 Applicable Standards

The CoNNeCT will follow applicable NASA standards including the mandatory standards in the development of the payload and associated systems. Those standards will be identified and listed in the Systems Requirements Document as the project enters into the critical design phase.

## 2.4 Designated Governing Authority

The GRC Director of Engineering is the governing authority for this SEMP. In the event of a conflict between this document and other project documents, this document shall take precedence over other documents except for the CoNNeCT Project plan.

# 3.0 TECHNICAL SUMMARY

The Software Defined Radios (SDR) currently proposed for space exploration missions lack the benefit of commonality or leverage from one development to another, increasing NASA's cost and dependence on single vendor solutions for communication and navigation radios. The SDRs offer a new operational capability. The CoNNeCT Project will advance the readiness of this technology for adoption by future missions and advance the interoperability among radio vendors and demonstrate multiple radio implementations compliant with a common architecture standard-- ultimately providing multiple industry sources of SDRs for future NASA missions.

Data gathered from the CoNNeCT experiments will demonstrate successful operation and reconfiguration among different signaling formats (e.g. communications with relay satellites, current and future global positioning satellite signal assessments) and assess the performance for Ka-band antenna pointing and tracking. The CoNNeCT experiments will advance the operational experience with current and emerging reconfigurable radio technology, its performance and impact.

## 3.1 System Description

The CoNNeCT Project is an on-orbit payload and ground control center used to conduct experiments to advance SDR technology and the STRS architecture, reduce risk and enable future mission capabilities. The CoNNeCT Project will provide NASA, SDR industry, other Government agencies, and academic partners the opportunity to develop and test communications, navigation, and networking technologies in a laboratory and space environment based on reconfigurable, SDR platforms and the STRS architecture. The CoNNeCT payload will consist of reconfigurable SDRs, a Radio Frequency (RF) subsystem operating at S-band, Ka-band, and L-band, antenna, and antenna pointing subsystem and an avionics subsystem for command and data handling, data storage, and networking systems (see figure 3.1-1 for CoNNeCT system block diagram).

The CoNNeCT payload will be mounted to a Flight Releasable Attachment Mechanism (FRAM) that supports common interfaces to carriers (see figure 3.1-2 for notional CoNNeCT layout on the FRAM). The FRAM provides structural interfaces to the carrier for launch and on orbit events. The CoNNeCT payload, mounted on a FRAM, will be integrated into the H-II Transfer Vehicle (HTV) for launch to the ISS. The Japanese Aerospace Exploration Agency (JAXA) is providing the HTV launch services. Once on orbit the payload/FRAM will be installed on an ELC that provides common interfaces to the ISS. Up to six FRAMs can be installed on a single ELC (see figure 3.1-3 for notional layout of ELC). The installation of CoNNeCT mounted on a FRAM onto the ELC will be by the robotic arm. No astronaut extravehicular activity is required. The CoNNeCT payload FRAM is launched mounted to an exposed pallet. The exposed pallet, with the CoNNeCT and FRAM on it, will be removed from the HTV by the ISS robotic arm. The exposed pallet is then handed off to the JEM arm and it is stowed on the JEM ELM-ES. The CoNNeCT payload, with it mounted to the FRAM, is then removed from the exposed pallet by the International Space Station (ISS) arm and mounted to the ELC. The exposed pallet does not get mounted to the ELC.

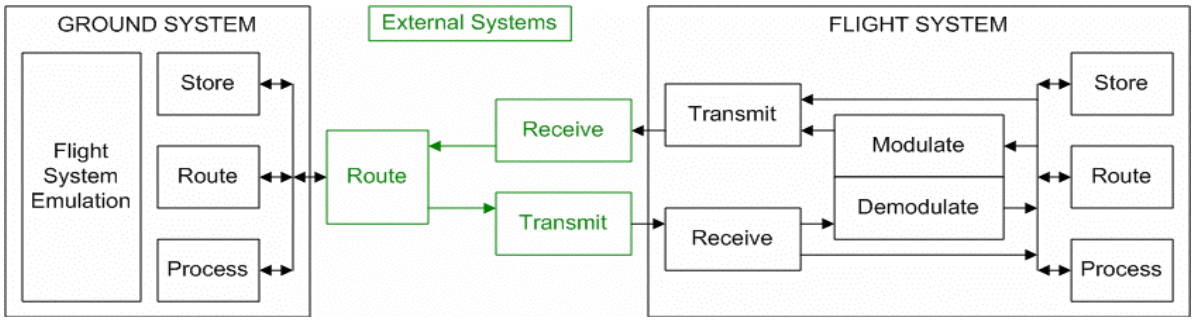


**Figure 3.1-1—CoNNeCT Block Diagram**

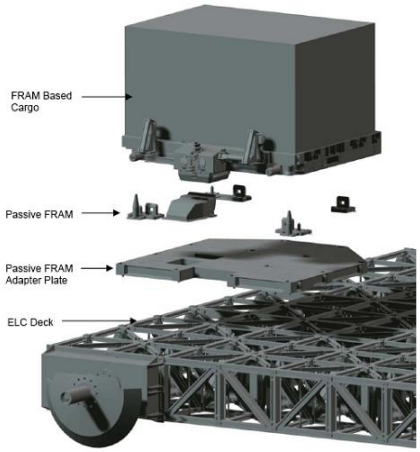


**Figure 3.1-2—Notional Layout on a FRAM.**

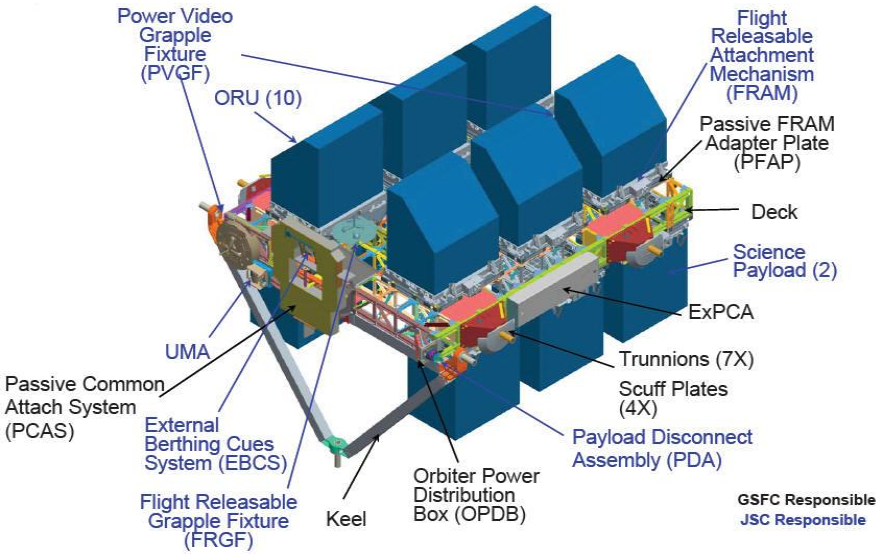


**Figure 3.1-3—ELC with FRAMs Installed.**

There are four nodes in the CoNNeCT communication network: 1) International Space Station (ISS), 2) Tracking and Data Relay Satellite System (TDRSS), 3) Global Positioning Satellite (GPS) constellation, and 4) to/from various ground stations. Figure 3.1-4 illustrates the connectivity between the CoNNeCT Control Center (CCC) in the Telescience Support Center at the GRC to the Huntsville Operations Support Center (HOSC) and Payload Operations and Integration Center (POIC) for tracking, telemetry, and control for operating the payload. Also, the diagram illustrates the connectivity between the CCC to the White Sands Space Network, and the Ground Station at Wallops Island. The TDRS links (not shown) are described as forward link from TDRSS to a user spacecraft and return link from the user spacecraft to TDRSS. In this case, the user spacecraft is the CoNNeCT payload on ISS. Radio waveforms on different CoNNeCT SDRs will operate over S-band Single Access, (SSA), S-band Multiple Access (SMA), and Ka-band Single Access (KSA). For some experiments, SDR(s) will also receive GPS signals.

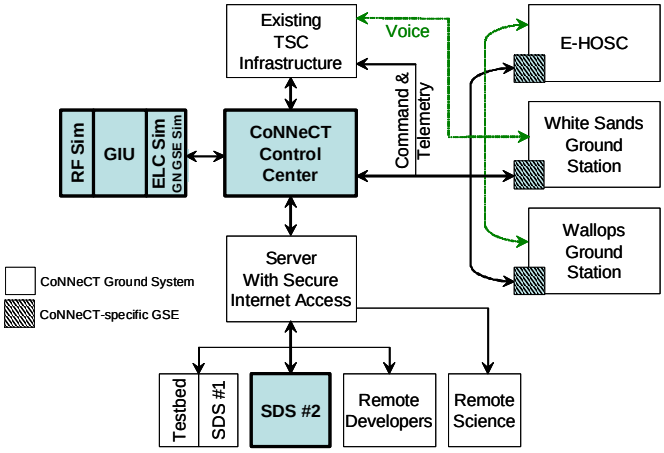


**Figure 3.1-4—CoNNeCT Communications Block Diagram**

## 3.2 System Structure and Hierarchy

The CoNNeCT WBS is shown below in figure 3.1-5 and defined further in Table 3-1. The CoNNeCT Project is managed out of the GRC SFSD with engineering support from the GRC ED (Code D). The ED is responsible for providing the engineering support including the Project Chief Engineer, Lead Systems Engineer, Software Lead and WBS leads in relevant areas. The Safety and Mission Assurance Directorate (S&MA) provides the S&MA oversight for the CoNNeCT Project. The Research and Technology Directorate is responsible for providing the Principal Investigator for defining the overall mission objectives, science requirements, and science and experiment aspects of the project. See section 4 of this document for external partner organization and responsibilities.

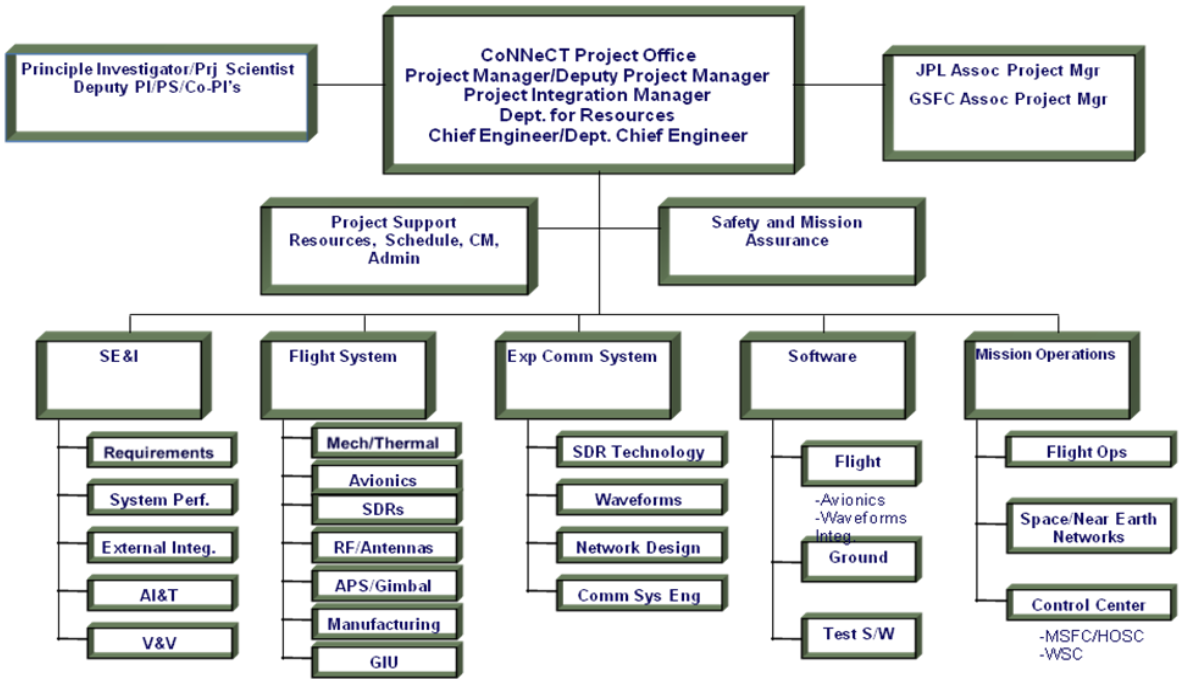


**Figure 3.1-5—CoNNeCT WBS Organization.**

### 3.2.1 Work Breakdown Structure (WBS)

The WBS is a hierarchical depiction of the system development activities as they relate to the CoNNeCT system architecture. The CoNNeCT Project has generated a product-based WBS model based on the business rules of NPR 7120.5D to concurrently develop the work products that will satisfy the CoNNeCT mission and that will satisfy the life-cycle support functions of the CoNNeCT system.

The project will use the WBS for:

- Identifying products, processes, data, documents and their assignments
- Identifying roles, responsibilities, accountability, project milestones and deliverables
- Technical, resource and schedule performance management
- Implementing configuration management and control of subsystems
- Organizing technical reviews and audits
- Reporting on technical, schedule, resource performance and risk

The work breakdown for the CONNECT Project is separated into product-oriented tasks that are briefly summarized in Table 3-1 below.

**Table 3-1—CoNNeCT WBS Dictionary**

| WBS # | Title | WBS Dictionary |
|---|---|---|
| 1.0 | CoNNeCT Project Management | This WBS element includes the effort for project planning, acquisition management, organizing, directing, coordinating, controlling, and approval processes used to accomplish the overall CoNNeCT Project objectives. |
| 1.1 | Project Management | This element includes overall project budget development and detailed cost phasing, including support of PPBE calls. This includes all project management tasks as executed by the PM, the Deputy PM, the Project Integration Manager and Associate PMs at the partner Centers GSFC and JPL. The PM is responsible for the overall management with a special focus on internal management of WBS elements 2, 3, 5, and 6. The DPM is the back-up to the PM and has special on external integration and mission operations of WBS elements 2, 3, and 7. The PIM is also a back-up to the PM with a special focus on CM, Resources, Documentation, Reporting and Risks. This element includes development and management of the overall project schedule. This element includes the development of a risk management plan to manage, monitor track, and buy-down identified risks. This element includes project reviews, status reporting, documentation, and support to the SCAN Program Office and the GRC Spaceflight Systems Directorate. |
| 1.2 | Business Management | This element includes overall multi-center project resource planning and development, including detailed program cost phasing, support of Planning Programming Budget and Execution (PPBE) calls, variance analysis, distribution of funding authority, and resource loading for contractor personnel. In addition, this element's role includes the position of Deputy for Resources (DR). The DR serves as the agency CoNNeCT resources manager and has project Agency-wide resources oversight across partner centers. The CoNNeCT DR coordinates across Centers during PPBE, provides narrative instructions to Headquarters for the guideline document, and works directly with the SCaN Program Business Manager to allocate and issue funding to the CoNNeCT partners. Overall management of resources includes: formulation of the Resources Management Plan, budget baselines, and preparation of FY Operating marks to Centers, validation of the financial WBS structure with Headquarters, issuing guidelines and policies, and budget formulation, analysis and reporting. The DR is the project |

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| | | custodian of project resources and the baseline. In addition, the DR serves as the project's business manager, ensuring project management support functions such as financial support, database support; administrative support, etc are addressed. The CoNNeCT DR is responsible for the implementation, management and provision of EVM reporting for the project based on EVM principles. The DR reports programmatically to the SCaN Program Business Manager, while working directly with the CoNNeCT Project Manager. |
| 1.3 | Configuration Management | Includes all subcontracts, labor, material, and other direct costs for configuration control consistent with NPR 7123.1. Includes drawings, specifications, documentation and hardware and software configurations. Includes data management tools & services for all engineering design, data, and parts information generated. Maintains data and information according to GRC product data management processes and practices; provide necessary indexing, referencing, storage, and retrieval functions via a networked environment that provides access by personnel. Assure compliance with ISO 9001, NPR 7120.5D, ITAR, EAR, etc. Includes Project and Risk control boards' official documentation. |
| 1.4 | Education and Public Outreach | Includes targeted activities to educate the general public and engineering and scientific communities. E&PO efforts are divided into CoNNeCT Phases 1 &2 where Phase 1 is general outreach associated with CoNNeCT as a comm technology platform. Phase 2 E&PO focuses on the science and technology from the ground and mission operations. Content includes web articles, brochures, technical conference papers, and STEM education products.GRC and partner Centers contribute to this area as resources allow. |
| | | |
| 2.0 | CoNNeCT Systems Engineering & Integration | The technical and management efforts of directing and controlling an integrated engineering effort for the project. This element includes the efforts to define the project space flight unit and ground unit system including software, conducting trade studies, the integrated planning and control of the technical program efforts of design engineering, specialty engineering, system architecture development and integrated test planning, system requirements writing, configuration control, technical oversight, control and monitoring of the technical program, and risk management activities. Documentation products include requirements documents, interface control documents (ICDs), and master verification and validation (V&V) plan. Excludes any design engineering costs and software engineering efforts which are covered in WBS 6.0. |

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| 2.1 | Systems Engineering Management | Includes all labor, subcontracts, materials and other direct costs to manage the systems engineering process and personnel necessary to support the mission. |
| 2.2 | Systems Req Def, Analysis & Mgt | Analyze, define, and document the system requirements; allocate them to system components; create and maintain a bi-directional requirements traceability matrix. Perform system-level analyses in support of design, development and test of the system. |
| 2.3 | System Assembly, Integration & Test | This WBS element provides for the planning, coordination and execution of system-level assembly, integration and testing of CoNNeCT hardware, and any associated ground support equipment. |
| 2.4 | System Verification & Validation | This WBS element determines whether the product or system and software fulfill all the design solution specifications and descriptive documents and whether the product accomplishes the intended purpose based on stakeholder expectations. Compliance is determined by a combination of test, analysis, demonstration, and inspection. |
| 2.5 | Technical Performance Metric Management | Technical Performance and Metric Management are conducted using a series of systems analyses. These system analyses support both the definition of systems requirements and the conduct of systems integration. System analysis accepts project objectives and provides system concepts, trade studies, performance analysis, cost analysis, and other analyses necessary to define a preferred system configuration and to assess the performance characteristics of the system as it proceeds through formulation and implementation. |
| 2.6 | External Integration | Ensures end-end processing of the flight system from originating site through transport for carrier installation, launch vehicle integration and launch, transportation to ISS and installation onto ISS ELC site. Ensures all activities associated with securing ISS Carrier transport for the CoNNeCT payload and all activities associated with securing CoNNeCT on launch vehicle manifest (currently targeting the HTV 3) are successfully accomplished per agreed schedule. Works with appropriate POCs at JSC, GSFC and other organizations to ensure payload is accommodated |
| | | |
| 3.0 | CoNNeCT S&MA | Includes all subcontracts, labor, material, and other direct costs for establishing and maintaining a mission level Safety and Quality Assurance Program. This includes Safety Data Package prep and reviews, reliability analyses, monitoring EEE part alerts, coupon testing, defective parts analysis, monitoring subcontractor and |

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| | | partner Quality Assurance Programs and the cost of maintaining a failure review board. |
| 3.1 | S&MA Management | Includes all labor, subcontracts, materials and other direct costs to manage the S&MA process and personnel necessary to support the mission. |
| 3.2 | Product Assurance & System Safety | The Product Assurance Plan (PAP) addresses all sections of the GRC SARG. The PAP documents how the project is going to meet the requirements of the SARG. Includes the cost of reviewing and monitoring subcontractor and partner QA reports, on-site inspections, and CPARS reporting system database management for CoNNeCT. Includes flight and ground safety data packages and reviews. Includes system reliability, availability, and maintainability. Includes all subcontracts, labor, material, and other direct costs for a mission level Failure Modes Effects Analysis and Single Point Failure Analysis to establish the probability of meeting mission requirements. Includes all subcontracts, labor, material, and other direct costs for implementing an independent software quality assurance program and to provide for an Independent Validation and Verification program of the flight software. Includes all subcontracts, labor, material, and other direct costs for establishing, maintaining and monitoring the Materials and Processes Control Program at the mission level. This includes establishing selection criteria for EEE parts, material manufacturing process guidelines, and monitoring subcontractor and partner compliance to the control program. |
| 3.3 | Continuous Risk Management | Includes an organized, systematic decision-making process that efficiently identifies, analyzes, plans, tracks, controls, communicates, and documents risk and establishes mitigation approaches and plans to increase the likelihood of achieving program/project goals. |
| | | |
| 4.0 | CoNNeCT Experiment Communication System | This WBS provides the overall science objectives, science requirements, and science and experiment aspects of the project. This WBS also suggests the mission success criteria (define and track) and monitors the system development to ensure that the science requirement will be met by the concept and subsequent design. This WBS will provide the science and technology requirements and operations concept and contribute to the concept of operations. This WBS serves as liaisons to potential phase II experimenters. |

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| 4.1 | Experiment Comm System Management | Includes all labor, subcontracts, materials and other direct costs to manage the Experiment Communication Systems WBS and personnel necessary to support the mission. |
| 4.2 | SDR Technology | The goal of this WBS is to understand the functionality and operation of the SDRs. This WBs includes the understanding of the functions and operations of the SDRs to enable future experiments, through the development of new software and firmware for the respective SDRs. Includes characterization testing and verification of experiments on breadboard, engineering, and flight models. Includes compliance with STRS function, operation, and performance. A comparison with functional requirements may be assessed, as appropriate. Includes operation, including any TDRSS services (e.g. ranging, timing) supported by the waveform, and development of software and firmware for the SDRs. |
| 4.3 | Waveforms | Develop STRS baseline TDRSS waveform for initial use on JPL SDR. Collaborate with GSFC for reuse of already developed TDRSS firmware and for TDRSS compatibility testing. Coordinate with JPL STRS Operating Environment development for waveform application integration. Follow NPR 7150 Class C software development requirements. Focus on non-coherent Data Group 2 TDRSS waveform for CoNNeCT. Development of the waveform will initially be done on a ground-based SDR-3000, then ported to a JPL breadboard BPM, and finally integrated on the JPL's flight radio. There is a core TDRSS firmware base on the SDR-3000 from which the needed CoNNeCT waveform functions will be extracted and modified to be STRS compliant. The SDR-3000 Development system will be used by GSFC and GRC to develop waveform code with JPL hardware specific considerations as part of the design. Upon receipt of the JPL breadboard (prototype) baseband processor module (BPM) the waveform code will be ported and tested with the available radio interfaces. Finally the waveform will be fully tested on the JPL radio flight unit when available. Full TDRSS compatibility testing will be at GSFC, but some simulation testing will be done prior at GRC. |
| 4.4 | Network Design | The goal of this WBS is to understand the functionality and operation of the network and experiment software operational on the avionics. It is critical to understand the functions and operations of these elements to enable future experiments, through the development of new software and firmware for the avionics subsystems. Includes network software, understanding of the functionality and operation of the network baseline software, compliance with STRS, and development of software and firmware for future network experiments. This WBS also includes an |

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| | | Experiment Development System (EDS) testbed designed to support experimenters in the design, development, operation and analysis of experiments to be conducted on the CONNECT system. This testbed will support experimenters with access to breadboard of each of the SDRs, integrated in a system with the other essential subsystems of the CONNECT Flight System simulated (e.g. avionics, channel, Space Network). |
| 4.5 | Communication SE&I | This WBS element accounts for an end-to-end Communication System Engineering function embedded with the Experimental Comm Team. The function is a traditional Systems Engineering role and this function serves as the primary interface between the Experiment Comm Team and the Systems Engineering Team in WBS 2.0. A key contribution of the function of this element is to monitor the end-to-end comm system development to ensure that the science requirement will be met by the concept and subsequent design. |
| | | |
| 5.0 | CoNNeCT Flight System | Flight System WBS element is to successfully develop requisite subsystems and ground support equipment for integration of the Flight System and support equipment for delivery to Verification and Validation. This includes the infrastructure for manufacturing, analysis, design and build. This element is responsible for the Mechanical System (includes Structural and Thermal design), Avionics System, Software Defined Radios (SDRs), RF system (including antennas), Automated Pointing System (APS), and any ground support equipment (GSE) including the Ground Integration Unit (GIU). |
| 5.1 | Flight System Management | Includes all labor, subcontracts, materials and other direct costs to manage the Flight System WBS and personnel necessary to support the mission. |
| 5.2 | Mechanical & Thermal | This WBS element covers all engineering and manufacturing resources (analysis, design, build, and test) for the structural and thermal systems. Structural systems include the FRAM, all secondary structures, and all fasteners and brackets necessary to complete the build-up of the integrated Flight System, Structural Test Article (STA) and any associated ground support equipment. Thermal systems include the analyses associated with the thermal performance of all flight hardware. |

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| 5.3 | Avionics | This WBS element covers all of the resources required to design, build, analyze, and test the avionics flight system from conception to turnover for flight. The deliverables within this element consist of an avionics enclosure (populated with circuit cards), instrumentation (for health/status monitoring), interconnects between payload packages, and avionics flight software. The avionics subsystem hardware is mounted to the ExPA through a secondary structural element (mounting plate) and interfaces to Express Logistics Carrier (ELC) resources, including: 28VDC power, 120VDC power, Ethernet communications, and MIL-STD-1553 communications. To the payload radios, the avionics subsystem provides SpaceWire communications, MIL-STD-1553, 28VDC power, and analog and digital input/output channels. The avionics subsystem also provides 120VDC power to the thermal control system heaters and 28VDC power to the RF Assembly. The hardware and software in this WBS element is comprised of both procured and in-house built items as noted in each lower-level WBS description. **Note:** Labor required during System Verification & Validation does **NOT** come out of this WBS, but comes from WBS 2.0, Systems Engineering & Integration. Deliverables: Procured and custom-developed hardware for avionics enclosure, flight software, instrumentation, interconnecting harnesses, design documentation, test reports, design review presentations, and any associated ground support equipment. |
| 5.4 | RF/Antennas | This WBS element covers all of the resources required to design, procure, fabricate, test and deliver the RF system (including antennas) for flight, including any associated ground support equipment. |
| 5.5 | Software Defined Radios | This WBS element covers all of the resources required to design, fabricate, test and deliver the SDRs for flight, including any associated ground support equipment. |
| 5.5.1 | General Dynamics | Design, development, testing, and delivery of the GRC SDR, including any associated ground support equipment. |
| 5.5.2 | Harris | Design, development, testing, and delivery of the Harris SDR, including any associated ground support equipment. |
| 5.5.3 | JPL | Design, development, testing, and delivery of the JPL SDR, including any associated ground support equipment. |
| 5.6 | Automated Pointing System | This WBS element covers the resources required to design and manufacture the gimbal actuator brackets that connect the two gimbal axes together and integration of the gimbal actuators onto their respective gimbal actuator brackets. This element covers the integration of the RF rotary joints to the gimbal actuators and |

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| | | connection of the rotary joints with coaxial cables and waveguide. This element covers the design and manufacture of the gimbal assembly to the gimbaled antenna interface and design and manufacture of the structure to mount the gimbal assembly onto the FRAM with final mounting and connection of the gimbaled antennas to the gimbal assembly. Deliverable: Integrated gimbal assembly & ground support equipment. |
| 5.7 | Manufacturing | This WBS element covers integrated logistics and the coordination for fabrication and assembly of the CoNNeCT hardware including the Structural Test Article, Engineering Models/Ground Integration Unit, and the Flight System. Material storage (including bonded stores) is supplied by this WBS function. Manufacture or acquisition of fixtures, shipping containers and unique support hardware are also provided by the function of this WBS element. |
| 5.8 | Ground Integration Unit | This WBS element covers all of the resources required to design, procure, fabricate, test and deliver the Ground Interface Unit. |
| | | |
| 6.0 | CoNNeCT Software | The CoNNeCT software element is to successfully develop requisite software for the Flight System, Ground System and related Testing of the CoNNeCT Flight or Ground Systems. This includes the software needed to test the flight or ground systems in any configuration that requires supplemental software other than the flight or ground packages. This element excludes software development by the experiment team which is contained in WBS 4.0. **Note:** In the financial WBS, Software is listed in WBS 12.0. |
| 6.1 | Software Management | Includes all labor, subcontracts, materials and other direct costs to manage the Software WBS and personnel necessary to support the mission. |
| 6.2 | Flight Software | This WBS element covers all of the resources required to design, build, integrate and test the avionics flight software. The element covers the cost of the operating system and tools required. It does not include any test software or simulation software created to do unit or interface testing at the component or subassembly level. It does not include any test software generated to support environmental testing or specific hardware component testing outside of the flight software baseline (functionality that does not exist in the flight software but is needed for things like stress testing hardware or interfaces). |
| 6.3 | Ground Software | This WBS is responsible for the design, development, integration and test of all software products to be utilized in the CoNNeCT Control Center (CCC) that communicate with the flight system, the |

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| | | CCC operators and any of the TSC. |
| 6.4 | Test Software | This element includes the software needed to test the flight or ground systems in any configuration that requires supplemental software other than the flight or ground packages. It includes any test software or simulation software created to do unit or interface testing at the component or subassembly level. It includes any test software generated to support environmental testing or specific hardware component testing outside of the flight software baseline (functionality that does not exist in the flight software but is needed for things like stress testing hardware or interfaces). |
| | | |
| 7.0 | CoNNeCT Mission Operations | This WBS is responsible for the overall coordination and implementation of all activities required to operate the CoNNeCT payload on the International Space Station (ISS), and conduct experiments through ISS, the Space Network (TDRSS) and the Ground Network stations at the Wallops Flight Facility and White Sands. The Mission Operations lead will interface with WBS sub-element leads, serving as the lead coordinator for payload communications and data interfaces definition and implementation. |
| 7.1 | Mission Operations Management | Includes all labor, subcontracts, materials and other direct costs to manage the Mission Operations WBS and personnel necessary to support the mission. This includes coordination with the PI & WBS leads to assure compatibility, development of plans and procedures to be used during flight experiment operations, and training of personnel to staff the CoNNeCT Control Center in support of the execution of pre-flight mission simulations, off-nominal operations, anomaly resolutions and the actual flight operations. |
| 7.2 | Space and Near Earth Networks | This WBS is responsible for conceptualizing, coordinating, and securing all CoNNeCT-unique ground network hardware/facilities/functions and coordinating TDRSS access and operations requirements associated with CoNNeCT space network experiments. The lead shall work with relevant organizations such as White Sands and NASA GSFC for TDRSS, the Wallops Flight Facility, the CoNNeCT Control Center lead, and any other relevant facilities. |

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| 7.3 | Flight Operations | This WBS ensures all planning, coordination, and operations execution is performed to ensure CoNNeCT mission operations are successfully accomplished. This WBS ensures CoNNeCT communications are successfully planned, coordinated and implemented. Operations shall be the primary interface with ISS Payload operations at the MSFC HOSC, and will coordinate extensively with Experiment Operations and Payload Health & Maintenance. CoNNeCT requirements and interfaces shall be documented and maintained in the Payload Data Library at MSFC.<br><br>This WBS element is also responsible for ensuring that the CoNNeCT payload is controlled, maintained and monitored while on-orbit in support of mission operations/experiments. This element will execute payload commands during operations, and perform payload anomaly resolution using the GIU. The lead shall work closely with the Mission Operations lead and the PI Experiment Operations Lead to assure that all experiments are proven on the GIU before being uplinked to, and executed on the flight system. During mission operations, personnel from the Experiment Comm and SE&I WBS elements will transition to this area to support on-orbit operations on an as- needed basis. This WBS will also coordinate closely with the Mission Operations WBS lead and project configuration control to develop and implement a tracking system for all of the WBS activities and reports. |
| 7.4 | CoNNeCT Control Center | This WBS is responsible for acquiring, establishing, maintaining and operating the hardware and software systems required for CoNNeCT command and telemetry processing, experiment execution, experiment data archiving and housekeeping data archiving. Computer hardware for primary and backup systems will be procured under this WBS element. This WBS element will also work with the Software WBS to assure that the C3 software is loaded on the C3 computer systems, and is verified and validated before flight. The WBS lead will be a lead position during operations. This element will also be responsible for integration and test of the C3 functionality with the GIU, working in concert with Payload Health & Maintenance. This element will also work with the TSC and the Payload Operation Integration Center at NASA MSFC to assure compatibility of the C3 with the TSC systems and the MSFC Huntsville Operations Support Center (HOSC). The WBS lead will work with the TSC to develop and maintain a C3/TSC IRD and ICD. The lead will also develop user guides and training manuals for the C3 and will train operators in its usage. |

## 3.3 Product Integration

This section describes the analytical and physical integration of the CoNNeCT flight system.

The current concept for the CoNNeCT Flight System is made up of several subsystems and components. The core of the payload consists of the three SDRs. The SDRs all exhibit design heritage from high technology readiness level product lines. The CoNNeCT Project is acquiring the SDRs through a combination of cooperative agreements in response to a NRA, and through an agreement established by NASA HQ.

Each radio supplier will deliver a breadboard unit, an engineering unit and a flight unit. The breadboard units will be integrated with Software Development System (SDS) 1 at the GRC. In all, there will be four SDSs. The SDS1 will be used initially for interface testing and then during the verification and validation phase of the flight hardware, it will then be used for PI work and experiment development.

The SDS2 will be used to test avionics interfaces and infrastructure control. The SDS2 is to be used by the software team for the duration of the project. The development systems will consist of an AC powered electronics system with non-radiation rated cards, and breakout boxes to allow testing of the different inputs/outputs. It will include the baseline complement of electronics cards.

The SDS3 will be a phased development, resulting in the engineering avionics to be used in the Ground Integration Unit (GIU). The SDS3 will become designated as the GIU, which will then be configuration managed and will be used to support flight operations. The development system will start with AC powered electronics system with the full complement of cards. The cards will be non-radiation tolerant cards, but with enhanced environmental performance. The system will be used as a test bed for the development of the custom cards. Upon completion of the software validation, the SDS3 will be upgraded into the GIU.

The GIU is the non-flight version of the flight system. This unit is to be used for software checkout and/or simulated on-orbit operations for the duration of the project. It will include the engineering model (EM) avionics and simulated pallet (structure and cabling). The EM hardware will be a phased development system eventually being used in the GIU. The GIU avionics is flight-like and maintains materials and handling heritage. The GIU includes a brassboard gimbal system and plans are to add a flight back-up TWTA. Avionics components of the GIU can be used as a flight spares in the event of a failure in the flight system ground processing or interface verification.

The fourth SDS will be used to support software development. It will use non-flight components and parts. It may include a hardware simulator which will simulate flight hardware so the software can be developed and tested.

Each of the three flight radios and RF subsystem will undergo testing at their supplier before being shipped to the GRC. Each flight radio and the flight RF subsystem will be shipped to GRC from the vendor where it will be integrated into the CoNNeCT payload. The radios will

come as box units and the RF subsystem will be mounted on a baseplate. The three SDRs will not be available until after the build-up begins, with the Harris Radio arriving after the Verification and Validation (V&V) phase is scheduled to begin. After the build and test phase, the integrated payload will be put through its V&V testing, followed by environmental testing.

The internal payload interfaces between the radios, the RF subsystem, the Antenna Pointing Subsystem avionics, and payload enclosure will be controlled by interface control documents and drawings that are owned by the CoNNeCT Project. The interfaces with the launch vehicle will be controlled by an ICD with JAXA, and the CoNNeCT interface with the ELC will be controlled by an ICD owned by payload integration manager at the JSC.

## 3.4 Technical Project Planning and Scheduling

The CoNNeCT Project shall comply with NPR 7123.1 Chapter 5, System Engineering Technical Reviews, for planning purposes as applicable to flight systems and ground support projects.

The CoNNeCT Master Schedule includes all major system subsystems by WBS. The Master Schedule was build using a combination of control dates (top down needs) and development schedules and linkages of each element (bottoms-up). The schedule is baselined at the time of major reviews such as PDR, and is configuration controlled requiring formal CCB approval. A roll-up of the ~1500-line Master Schedule is shown in Figure 3.4-1 below.

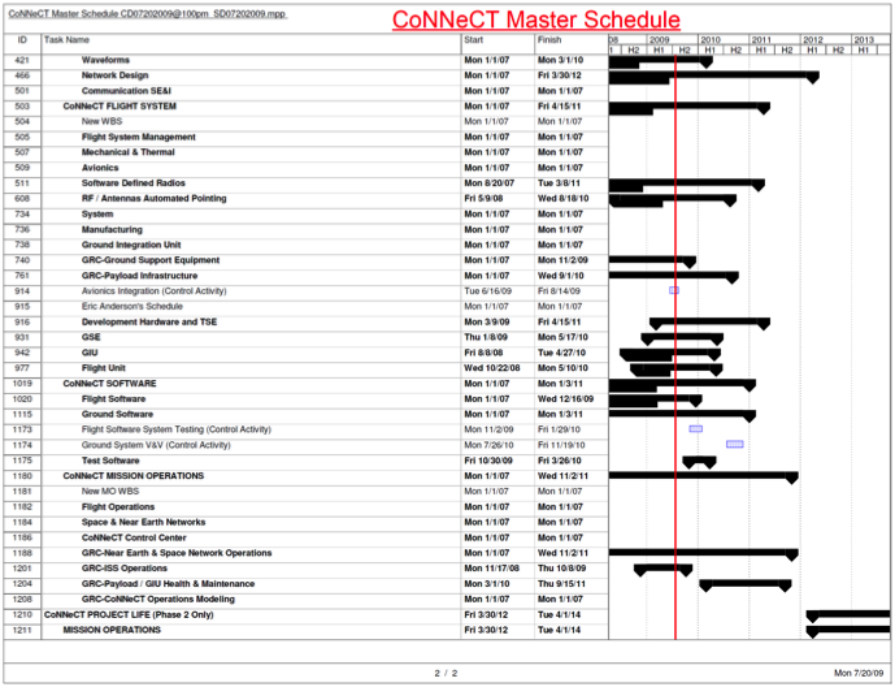


**Figure 3.4-1—CoNNeCT Project Timeline**

### 3.4.1 Standing Review Board (SRB)

An SRB as described in NPR 7120.5 will be convened as the review board for the four major reviews that are planned. The SRB will consist of a chair, review manager and members and may be augmented with Subject Matter Experts from the GRC and Engineering Community independent of the CoNNeCT Project. The SRB will remain intact throughout the project's life. The four major reviews are the Preliminary Design Review (PDR), Critical Design Review (CDR), Test Readiness Review (TRR) and System Acceptance Review (SAR). The CoNNeCT Chief Engineer (CE) will chair the other reviews cited in 7123.1, the Software Review Board Chair will chair software specific reviews, and the Payload Safety Panel will chair safety specific reviews. These major reviews, along with all of the other engineering reviews, are described below.

### 3.4.2 Project Reviews

Below is the list of milestone reviews as applicable to the CoNNeCT Project. The CoNNeCT Project will comply with NPR 7123.1 and GLPR 7123.35 in the conduct of all milestone reviews. Table 3-2 shows the remaining CoNNeCT reviews.

**Mission Concept Review/System Requirements Review (MCR/SRR)**
The CoNNeCT SRR was conducted in May 2008 at the end of the formulation phase. The primary objective of the SRR was to confirm that the CoNNeCT requirements are complete, verifiable, properly flowed down and traceable, validated, allocated to the component level, responsive to mission requirements and capable of fulfilling mission needs, and are of sufficient maturity with acceptable risks to warrant moving forward to the next program phase.

**Software Requirements Review (SWRR)**
The CoNNeCT SWRR was conducted in November 2008. The primary objective of the SWRR was to confirm that the CoNNeCT software requirements are complete, verifiable, properly flowed down and traceable, validated, allocated to the component level, responsive to mission requirements and capable of fulfilling mission needs, and are of sufficient maturity with acceptable risks to warrant moving forward to the next program phase.

**Software Architecture Review (SWAR)**
The CoNNeCT SWAR was conducted early in the software design phase. The primary objective of the SWAR is to demonstrate that the chosen software architecture provides a structure that supports meeting all software requirements and quality attributes with minimum risk. The focus of the SWAR is on identifying the major software components of the system and detailing the interfaces between them. The software architecture allows analysis of the flow of information throughout the system. It also establishes the basis for proceeding with detailed design. Successful completion of the SWAR will result in the authorization to proceed to final software design in accordance with the reviewed approach. The SWAR will be an internal the GRC review. Review material, viewgraphs, pages, etc., which are restricted and limited in their dissemination under the International Traffic in Arms Regulations (ITAR) will be marked accordingly.

**Preliminary Design Review (PDR)**
The CoNNeCT PDR is planned for September 2009. The primary objective of the PDR is to demonstrate that the preliminary design meets all subsystem level requirements with acceptable risk. It should show that the correct design option has been selected, interfaces have been defined, and verification methods have been identified. It should also establish the basis for proceeding with detailed design. Successful completion of the PDR will result in the authorization to proceed to final design in accordance with the reviewed approach, interface requirements, commonality items, and approval to update the baseline documentation. An SRB will review the project at this review. Appendix A shows the review requirements from 7123.5 and how the project expects to meet those requirements. Individual review material, viewgraphs, pages, etc., which are restricted and limited in their dissemination under the ITAR will be marked accordingly.

The project's interpretation and implementation of the success criteria from NPR 7123.1 and NPR 7120.5 are also shown in Appendix A. Those criteria are modified versions of PDR criteria used at GSFC and are more specific, but very comparable, to the ones listed in the NPRs. Additionally, two criteria are added to the success criteria that are similar to the entrance criteria in 7123.1. The Standing Review Board will evaluate the CoNNeCT project on the items listed in the table.

**Phase 0/1 Flight Safety Review (FSR)**
A Phase 0/1 FSR will be conducted with the Payload Safety Review Panel at JSC. A JAXA Safety Review Panel representative will participate in this review. The project's safety personnel will present the payload's hazards and controls to the review panel.

**Software Design Review (SWDR)**
The CoNNeCT SWDR will be conducted with a Software Review Board Chair following the project PDR. The primary objective of the SWDR is to demonstrate that the software design accommodates implementation of all software requirements with minimum risk. The focus of the SWDR is on traceability of the software requirements to the design and that sufficient planning has been done for software testing. The software design allows analysis of the timing and performance of the system. It also establishes the basis for proceeding with coding of the flight code. The possibility of Safety Critical Flight Software exists. The approach for this software development will be reviewed. Successful completion of the SWDR will result in the authorization to proceed with final software development in accordance with the reviewed approach. The review board will have SRB representation and will be augmented with specific software reviewers. Review material, viewgraphs, pages, etc., which are restricted and limited in their dissemination under the ITAR will be marked accordingly.

**Phase II Flight Safety Review**
A Phase II Flight Safety Review will be conducted with the Payload Safety Review Panel at JSC. A JAXA Safety Review Panel representative will participate in this review. The project's safety personnel will present the payload's hazards and controls to the review panel.

## Critical Design Review (CDR)

The CoNNeCT system CDR will be conducted when the detailed design is approximately 90 percent complete for configuration items. The purpose is to determine the compliance of the completed design with the baselined requirements. The review will address the CoNNeCT flight system, ground operations and ground support systems. Successful completion of the CDR will result in the authorization to continue with fabrication and assembly. The SRB will be the reviewing body for the CDR. Appendix A shows the review requirements from 7123.5 and how the project expects to meet those requirements. Individual review, viewgraphs, pages, etc., which are restricted and limited in their dissemination under the ITAR will be marked accordingly.

Prior to the CoNNeCT system level Critical Design Review (CDR) and prior to assembling mechanical and avionics subsystem hardware, the Mechanical Subsystem and Avionics Subsystem will hold an Integrated Subsystem CDR.

The Integrated Mechanical-Avionics (Mech-Av) Subsystem CDR will be conducted by the CoNNeCT Engineering Review Board (ERB) per GLPR 7123.36 with the CoNNeCT Chief Engineer as the review chair. The Standing Review Board, CoNNeCT WBS Leads and the GRC Discipline Lead Engineers (DLE) will be represented on the ERB. The review board will consist of reviewers with expertise in the following areas at a minimum: Thermal, Structural, Electrical, Design, Manufacturing, Space Hardware Development, and Project Management.

An Integrated Mech-Av Subsystem CDR Plan will be approved by the CoNNeCT Chief Engineer, Lead Systems Engineer, appropriate DLEs and the Systems Engineering Division Chief. The plan will show the Review entrance and success criteria, and will list the subsystem products that will be provided as evidence that the criteria are met. Additionally, the plan will describe the review process and review team membership by skill.

## Production Readiness Review (PRR)

This review is not applicable to CoNNeCT because a PRRis held for flight systems and ground systems (FS&GS) projects developing or acquiring multiple or similar systems greater than three. CoNNeCT will build only one unit.

## System Integration Review (SIR)

The CoNNeCT Project will conduct multiple Integration Reviews which ensure that the components are ready to be integrated. The reviews will be held as the components become available and will verify that they are available and ready to be integrated into the system. The reviewers will also assess if the integration facilities, support personnel, and integration plans and procedures are ready for integration. A CoNNeCT ERB will be the reviewing body for this review. The CoNNeCT CE will chair the review. The ERB membership may include members from the SRB. Review material, viewgraphs, pages, etc., which are restricted and limited in their dissemination under the ITAR will be marked accordingly.

**Test Readiness Review (TRR)**
The CoNNeCT Project will conduct multiple TRRs as a precursor to formal integrated testing or testing on systems and components that have been identified as critical. A TRR verifies that the tests will be conducted in accordance with program requirements, good test practices, and safety rules and regulations. Successful completion of these reviews will ensure that test objectives are correctly identified and met in test. The SRB will be the reviewing body for the TRRs. TRRs will be conducted for the system vibration test, communication performance tests, thermal vacuum test, EMI test and closed loop pointing test. Appendix A shows the review requirements from 7123.5 and how the project expects to meet those requirements. Individual review, viewgraphs, pages, etc., which are restricted and limited in their dissemination under the ITAR will be marked accordingly.

**Phase III Flight Safety Review**
A Phase III Flight Safety Review will be conducted with the Payload Safety Review Panel at JSC. A JAXA Safety Review Panel representative will participate in this review. The project's safety personnel will present the payload's hazards and controls to the review panel.

**System Acceptance Review (SAR)/**
A SAR will be conducted prior to shipping the flight system. It will demonstrate that the "as-built" configuration, physical, functional, and performance requirements have been verified to the data submitted in the Acceptance Data Package; qualification and acceptance testing is completed; parts, processes, and materials used are qualified;, and any waivers or deviations have approved documentation; any failures have been isolated, repaired, and satisfactorily retested with no pending failure analyses; and non- conformance reports are properly dispositioned. The SRB will be the reviewing body for the SAR. Appendix A shows the review requirements from 7123.5 and how the project expects to meet those requirements. Review material, viewgraphs, pages, etc., which are restricted and limited in their dissemination under the ITAR will be marked accordingly.

**Operational Readiness Review (ORR)**
The ORR examines the actual system characteristics including the procedures used in the system or end products operation and ensures that all system and support (flight and ground) hardware, software, personnel, procedures, and user documentation accurately reflect the deployed state of the system.

The ERB will be the reviewing body for the ORR. Appendix A shows the review requirements from 7123.5 and how the project expects to meet those requirements. Review material, viewgraphs, pages, etc., which are restricted and limited in their dissemination under the ITAR will be marked accordingly.

**HTV Flight Readiness Review (FRR)**
CoNNeCT is required to support the JAXA HTV FRR which is modeled after the ISS FRR. This review will take place in Tsukuba, Japan, and will be represented by every payload (pressurized and unpressurized) on and systems of the HTV. The payloads will report through a modified Certificate of Flight Readiness (CoFR) that is a subset of the ISS Payloads Office

CoFR. This review centers around the collective payloads completion of actions, completion of verifications; specifically, safety for both the launch vehicle and the ISS and interface verifications, and closure of ground processing anomalies. At the completion of this review, the HTV will be certified ready to launch.

**Flight Readiness Review (FRR)**
The CoNNeCT Project will support the ISS FRR via the Payload CoFR process. The FRR and CoFR process determine the system's readiness for a safe and successful flight and for subsequent flight operations. It also ensures that all flight and ground hardware, software, personnel, and procedures are operationally ready.

**Phase 0/I/II Ground Safety Review-Japan (GRS)**
CoNNeCT is required to support the combined Phase 0/I/II GSR at either Tsukuba or Tanegashima, Japan. This review is patterned after the KSC GSRs. This review will center on CoNNeCT ground processing at the Tanegashima Launch Facility with particular focus on the types of processing, hazards that could result and controls of those hazards. The fidelity of review is identical to that of the Shuttle or ISS payload safety reviews. At the completion of this review, CoNNeCT would expect to be at the same fidelity as the KSC Phase II GRS. It should be noted that JAXA has board membership on both the NASA GSR Board and the Flight SRB and that information provided to either of these boards is relayed to the JAXA SRB.

**Phase III Ground Safety Review (Japan)**
CoNNeCT is required to support the Phase III GSR at either Tsukuba or Tanegashima, Japan. This review is patterned after the KSC Phase III GSR. This review will center on CoNNeCT ground processing at the Tanegashima Launch Facility definition of the precise ground processing, hazards that will result and specific controls of those hazards. The board will review the ground safety verification log and any closures performed to date. The fidelity of review is identical to that of the Shuttle or ISS payload safety review. At the completion of this review, we would expect to be at the same fidelity as the KSC Phase III GSR. It should be noted that JAXA has Board Membership on both the NASA GSR Board and the Flight SRB and that information provided to either of these Boards is relayed to the JAXA SRB.

**Post-Launch Assessment Review (PLAR)**
A PLAR is a post-deployment evaluation of the readiness of the spacecraft systems to proceed with full operations. The review evaluates the status, performance, and capabilities of the project evident from the flight operations experience since launch. This can also mean assessing readiness to transfer responsibility from the development organization to the operations organization. The review also evaluates the status of the project plans and the capability to conduct the mission with emphasis on near-term operations and mission-critical events. This review is typically held after the early flight operations and initial checkout.

A CoNNeCT ERB will be the reviewing body for this review. The CoNNeCT CE will chair the review. The ERB membership will include independent reviewers and possibly members from the SRB. Review material, viewgraphs, pages, etc., which are restricted and limited in their dissemination under the ITAR will be marked accordingly.

### Critical Event Readiness Review

This review is not applicable.

### Post-Flight Assessment Review (PFAR)

The PFAR evaluates the activities from the flight after recovery. This review is not applicable to CoNNeCT.

### Decommissioning Review (DR)

A DR confirms the decision to terminate or decommission the system and assesses the readiness of the system for the safe decommissioning and disposal of system assets. This review is not applicable to CoNNeCT Phase One activities.

**Table 3-2—Remaining CoNNeCT Reviews**

| Review | Review Board |
|---|---|
| Software Architecture Review | SW RB |
| Preliminary Design Review | SRB |
| Phase 0/1 Flight Safety Review | PSRP |
| Phase II Flight Safety Review | PSRP |
| Phase III Flight Safety Review | PSRP |
| Critical Design Review | SRB |
| Software Design Review | SW RB |
| Phase 0/I/II Ground Safety Review | JAXA SSRP |
| Production Readiness Review | Not Applicable |
| System Integration review | ERB |
| Test Readiness Review | SRB |
| Phase III Flight Safety Review (JAXA) | JAXA SSRP |
| System Acceptance review | SRB |
| Operational Readiness Review | ERB |
| HTV Flight Readiness Review (JAXA) | JAXA SSRP |
| Flight readiness Review | ERB |
| Post Launch Assessment review | ERB |
| Critical Event Readiness Review | Not Applicable |
| Post Flight Assessment review | Not Applicable |
| Decommissioning Review | Not Applicable |

## 3.5 Boundary of Technical Effort

The CoNNeCT SEMP has control over the issues within its own technical boundaries as defined by the CoNNeCT WBS. Influences on the system that are outside the CoNNeCT WBS system boundary will require coordination with external organizations as required.

The effort includes Flight System and Ground System, and CoNNeCT subsystems. It does not include TDRSS, the Space network or the Ground Network.

The SE functions within the CoNNeCT WBS system boundary include:

- Subsystem requirements development, decomposition and management
- Subsystem definition, design, modeling and simulation, analyses, and trades
- Integrated ground testing and demonstration (breadboard, engineering, GIU, and flight)
- Subsystem integration
- SE&I (requirements and verification development, interface definition, operations, logistics, and overall system modeling, layout, and analysis)
- The SM&A support (safety, reliability, risk identification and mitigation, quality assurance, materials & processes, and software/hardware product assurance)
- Concept of operations and logistics
- Structure and thermal, avionics, ground ops interface support
- Prepare and conduct any subsystem reviews
- Prepare data requirement documents
- V & V planning, implementation and documentation

## 3.6 Standards, Procedures, and Training

Where appropriate, the standards and procedures established by NASA, the GRC, and industry shall be utilized. This includes all applicable NASA Procedural Requirements (NPRs), Glenn Procedural Requirements (GLPRs), and industry standards along with applicable carrier and ISS requirements. Also, standards specified in the CoNNeCT Project Plan, GRC-CONN-PLAN-0004 will be adhered to. Standards and procedures used by the CoNNeCT Project will be documented and tracked by the CoNNeCT CM team. Standards and procedures used will be referenced in all project documentation generated by the CoNNeCT team.

Standards and procedures used by partners/subcontractors will be subject to evaluation, review, audit and/or inspection by NASA GRC or its designated representatives. Training requirements will be determined by the project team with approval by the PM.

CoNNeCT will also comply with the mandatory technical standards established by NASA.

## 3.7 Technical Communication

Due to the numerous team partners supporting CoNNeCT across multiple NASA Centers and contractors, regular and open communication between the CoNNeCT team is essential. In addition to the system project life cycle reviews, the CoNNeCT Project will make every effort to utilize available communications technology and tools to facilitate the exchange of information. These efforts are outlined in the following sections:

### 3.7.1 CoNNeCT Engineering Review Board (ERB)

The CoNNeCT ERB as described in GLPR 7123.36 and the CoNNeCT Project Plan will be chaired by the CoNNeCT CE. The ERB members will include the LSE, Software Lead, Experimental Communications Systems Lead, the Flight System Lead, Mission Operations Lead, and the CoNNeCT SM&A representative. The CE will solicit Discipline Lead Engineers and Subject Matter Experts to be members depending on the content of technical issues. The PM and PI are ex-officio members. See the ERB charter in the Project Plan GRC-CONN-PLAN-0004.

The ERB will disposition all engineering issues brought before the board. The ERB resolution and all documentation will be given to the Project Configuration Manager for archiving. The ERB will review engineering reports, design review documentation, and investigate engineering issues. The ERB decisions impacting programmatic issues will be reviewed and dispositioned by the CoNNeCT Control Board (CCB). The CoNNeCT Project Plan contains the CCB charter and members.

The GRC Chief Engineer and the Director of Engineering hold weekly meetings called Engineering Management Boards. The CoNNeCT Chief Engineer will be a regular participant in these meetings and will discuss issues requiring management action. The Center level board is the Center Management Council which may be used to resolve issues that cross directorate boundaries.

### 3.7.2 Technical Interchange Meeting (TIM)

The TIMs will be held as needed on specific technical issues or topics that require involvement of more than one of the CoNNeCT radio providers or other NASA Centers. Besides technical design issues, a TIM may address any, or all, of the engineering specialties described in Section 7.0 of this document. Prior to each TIM, the agenda shall be distributed to the project team members. At the completion of each TIM, meeting minutes, including attendance and action items, will be documented, distributed and filed with all other project documentation.

### 3.7.3 Weekly CoNNeCT Technical Integration Meetings (CTIM)

The CoNNeCT Chief Engineer will nominally conduct weekly meetings with the GRC subsystem teams to status and coordinate all Project, SE and technical integration issues. This meeting is also used to vet and review progress and new developments that cross subsystem boundaries.

### 3.7.4 Working Group Teleconferences

Telecons will be held as necessary at the working group level (e.g., mechanical, electrical, software, integration, etc.) to enable detailed interactions between the project stakeholders. At the completion of each telecon, meeting minutes, including attendance and action items will be documented, distributed and filed with all other project documentation.

### 3.7.5 eRoom Web-based Collaboration

The GRC has setup a secure, web-based collaboration workspace for the CoNNeCT Project team to communicate and coordinate work with each other. All team members are invited into the eRoom workspace that contains project data, organization contact information, presentations, and other useful information needed to conduct work activities. The eRoom collaboration allows virtual teams to share information, draft documents together, manage team actions, manage team schedules, manage workflow, manage project plans, communicate via threaded email discussions and make team decisions.

# 4.0 TECHNICAL EFFORT INTEGRATION

The CoNNeCT Project WBS was shown and discussed in section 3.2 and provided a graphic representation of the GRC CoNNeCT Project structure. In figure 4.0-1 below shows the CoNNeCT organization with the external partners.

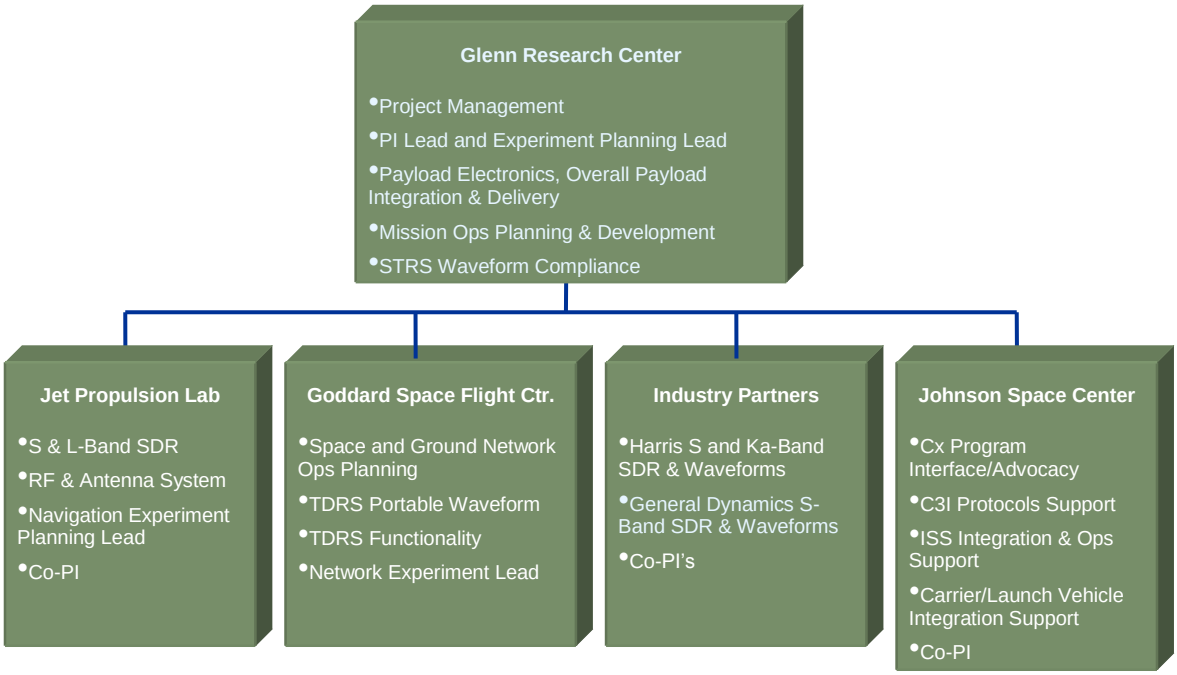


**Figure 4.0-1—CoNNeCT Partner Organizations**

## 4.1 NASA Glenn Project Management Organization

The GRC has been delegated responsibility for implementing the CoNNeCT Project by the NASA HQ SOMD's Space Communications and Navigation (SCaN) Program Office. The GRC Space Flight Systems Directorate will be responsible for the PM of CoNNeCT. The project will be managed in accordance with the NASA policy guide for PM (NPR 7120.5D). There will be a single GRC PM who will lead the project.

## 4.2 NASA Glenn Engineering Organization

The GRC will provide engineering support responsible for the technical leadership and horizontal integration across the CoNNeCT Project team at all the partners (GRC, GSFC, JPL, GD, Harris and JSC). The Chief Engineer will provide technical and management efforts of directing and controlling an integrated engineering effort for the project. This includes the efforts to define the project space flight unit and ground unit system, integrated planning and control of the technical program efforts of design engineering, and system architecture development.

The systems engineering team is led by the LSE. The LSE is responsible for directing the practice of systems engineering in accordance with NPR 7123.1A and to assure the delivery of the integrated CoNNeCT system in accordance with stakeholder requirements.

Systems engineering provides two major functions for the project; 1) typical system engineering support, using project dedicated systems engineers, and 2) integration and coordination of the technical baseline across all technical teams.

Nominal CoNNeCT system engineering functions include:

(a) The system requirements function responsible for all system level requirements, as well as coordinating subsystem and lower level requirements with the technical teams. This includes requirements development and definition, allocation, traceability, and verification support. The requirements group also has the prime responsibility to define and control all external interfaces, but works with the subsystem technical team leads, to define and control all internal interfaces,

(b) Providing engineering specialties support.

(c) The system design function supporting the requirements group to ensure all external and internal interfaces are compatible.

(d) Flight hardware assembly, integration and testing activities.

(e) Verification and validation planning and activities.

(f) Ground integration activities at the launce site.

The SE&I also provide support for the Configuration/Data Management element in its configuration and data management function.

The engineering design team conducts trade studies, software engineering and specialty engineering. The engineering team provides physical integration of the avionics, RF, antennal pointing system, and the software defined radios. They also perform the build and test sequence before turning the hardware over to SE&I for verification and validation.

## 4.3 Project Responsibility

### 4.3.1 GRC Project Management Responsibility

The GRC PM responsibilities are defined in the CoNNeCT Project Plan, GRC-CONN-PLAN-0004. While the CoNNeCT PM has full responsibility and accountability for the execution of the project as defined in NPR 7120.5D and the CoNNeCT Project Plan, meeting all requirements will necessitate support from participating project team organizational representatives.

### 4.3.2 NASA GRC Engineering Development Responsibility

The GRC development team is responsible for the system integration activities for the CoNNeCT payload and ground support system. CoNNeCT will be developed under the proto-flight approach and the environmental testing limits are defined in the CoNNeCT Verification and Validation Plan (GRC-CONN-PLAN-0012). There is no qualification model being developed for CoNNeCT. The GRC development or engineering team consists of technical staff from various organizations across the GRC. The GRC team will develop and specify the requirements and procedures for ground test and verification of the CoNNeCT payload and ground support system. The GRC team will provide verification to the ISS Payload Integration Function which in turn will integrate it into the overall documentation and requirements for the ISS integrated payloads for the proposed HTV flight. This will include the integrated HTV requirements and integration agreements, integrated ELC requirements and integration agreements, physical integration on the ISS, and ISS operations requirements. The GRC team will ensure that ISS payload integration function provides the appropriate flight payload accommodations, engineering support, mission unique hardware and software, CoNNeCT to ELC integration support, payload safety certification, facilities for final assembly at the HTV processing facility, testing and checkout, NASA control center accommodations for operation and monitoring, and provide housekeeping and science data to the CoNNeCT team as required for the mission.

The NASA GRC team will have the responsibility for the following documents, matrices, engineering activities, and plans:

- System Requirements Document
- Systems Engineering Management Plan
- Requirements Traceability Matrix
- Requirements Verification Matrix
- V&V Plan
- Test Plans
- Concept of Operations Document

- Development of the Operations Concept

- Design, build, and test of the payload

- Design, develop, and test the system software

- Perform the verification and validation of the CoNNeCT System

- Perform Mission through initial on-orbit checkout (Phase I only)

In addition to the payload development and integration, the GRC team also has overall technical responsibility for the development and delivery of the communications instrument for the payload. The GRC will manage the delivery of key deliverables from its CoNNeCT partners (as described below) for the communications instrument including the SDRs to be delivered by JPL,

Harris and GD, the RF subsystem and antennas to be delivered by JPL, as well as the STRS-compliant waveform(s) to be developed jointly by the GSFC and the GRC. Finally, the GRC development team will lead and manage activities associated with preparation for mission operations to include coordination and planning with TDRSS, the Space and Ground Networks, and the development of the CCC. The GRC will work with its partners in ensuring the project is ready to enter experiment mission operations post-launch.

### 4.3.3 GRC Principal Investigator Responsibility

The GRC technology development team will provide lead PI duties that include generating experiment requirements and leading the experiment planning for CoNNeCT. The GRC will also co-lead the network experiment planning. The GRC PI team will have the responsibility for the following documents:

- Operational Concept Document
- Science and Technology Requirements Document
- Experiment Plan

### 4.3.4 Jet Propulsion Laboratory (JPL) Responsibility

The JPL responsibilities include delivery of one flight SDR, with breadboard and engineering model (EM) with documentation and an integrated RF subsystem and antennas. Other responsibilities include co-PI duties to provide science and technology requirements, support for integration of their radio, experiment requirements and planning as well as participating in on-orbit experiment operations, and serve as the navigation co-PI lead.

The JPL has an Associate PM (APM) to support the GRC PM. The APM, as part of the PM team, serves as the programmatic interface to JPL for the PM. The APM will be responsible for supporting the PM and DPM in PM duties for work performed at JPL and addressing institutional issues impacting the project with appropriate line management at their facility. As such, the APM is responsible that work at JPL meets project requirements within project allocated resources, products are delivered per agreed to schedule and risks are appropriately managed and mitigated.

### 4.3.5 Harris Corporation Responsibility

Harris' responsibilities include delivery of one flight SDR, with breadboard and EM with documentation and other deliverables as outlined in the CoNNeCT/Harris CA NNC09AA01A. A flight waveform will be delivered. Other responsibilities include support for integration of their radio, experiment requirements and planning as well as participating in on-orbit experiment operations.

### 4.3.6 General Dynamics (GD) SDR Provider Responsibility

The GD's responsibilities include delivery of one flight, breadboard and EM SDR with documentation and other deliverables as outlined in the CoNNeCT/GD Cooperative Agreement. The delivery includes a flight waveform. Other responsibilities include support for integration of

their radio, experiment requirements and planning as well as participating in on-orbit experiment operations. GD is working under a cooperative agreement with the GRC.

### 4.3.7 Goddard Space Flight Center (GSFC) Responsibility

The GRC and GSFC will jointly develop an STRS-compliant S-band TDRSS waveform for porting onto the JPL radio. The GSFC responsibilities also include liaison activities with the TDRSS Program Office, and implementing the communications architecture on CoNNeCT. GSFC will also be responsible for the design, implementation, and operation of the Ground Network System (GNS). The GNS consists of all CoNNeCT unique systems that are required to establish and operate the communications link between the NASA GRC CCC and the NASA Space Network (SN) and NASA Ground Network (GN).

The GSFC has an APM to support the GRC PM. The APM, as part of the PM team, serves as the programmatic interface to GSFC for the PM. The APM will be responsible for supporting the PM and DPM in PM duties for work performed at GSFC and addressing institutional issues impacting the project with appropriate line management at their facility. As such, the APM is responsible that work at GSFC meets project requirements within project allocated resources, products are delivered per agreed to schedule and risks are appropriately managed and mitigated.

### 4.3.8 Johnson Space Center-OZ ISS Payloads Office (JSC-OZ) Responsibility

The CoNNeCT Payload Integration Managers (PIM) are located at JSC-OZ. The PIM functions as the CoNNeCT primary interface to the ISS program and the JAXA program and they have several responsibilities. The ISS PIM will ensure all of the documentation to fully define the interface between the ISS/ELC and CoNNeCT. This includes the Payload Integration Agreement (PIA), and the ISS/ELC Hardware and Software ICDs. The PIM will also facilitate payload integration product development, delivery schedules, and communications with the ISS program as well as NASA ground communication facilities. The JAXA PIM will ensure all of the documentation to fully define the interface between the HTV and CoNNeCT.

### 4.3.9 Kennedy Space Center (KSC) Responsibility

KSC will provide support facilities during pre-launch and ensure that all CoNNeCT GSE meets KSC requirements and specifications. CoNNeCT will utilize a facility at the KSC for testing the CoNNeCT avionics with the ExPCA. All of the furnished equipment and services described are to be provided to CoNNeCT and are not part of the project's budget.

Normally, ELC testing at KSC would occur however, the project is making arrangements for the ELC to be shipped to GRC. Support personnel will travel to GRC to perform ELC tests with the integrated CoNNeCT Payload.

### 4.3.10 Marshall Space Flight Center (MSFC) Responsibility

The MSFC will provide payload communication and control support at the HOSC. The JSC-OZ, in cooperation with CoNNeCT will provide all data to integrate payload operations into the HOSC.

### 4.3.11 White Sands Test Facility (WSTF) Responsibility

The WSTF will ensure that all CoNNeCT GSE meets WSTF requirements and specifications.

### 4.3.12 Wallops Flight Facility (WFF) Responsibility

The WFF will ensure that all CoNNeCT GSE meets WFF requirements and specifications. JSC-OZ, in cooperation with CoNNeCT will provide all data to integrate payload operations into the WFF.

# 5.0 SYSTEMS ENGINEERING PROCESS (COMMON TECHNICAL PROCESSES IMPLEMENTATION)

## 5.1 System Design Processes

The intent of this section is to provide a description of how each of the 17 common technical processes prescribed within SE NPR 7123.1 will be implemented within the CoNNeCT Project. Appendix C of NPR 7123.1 shows a representative figure of each of the 17 common technical processes. NPR 7123.1 also states within Section 1.1.6 that "Figures within this NPR are not intended to be prescriptive but notional." It is for that reason that the CoNNeCT Project will tailor the approach used to implement the 17 common technical processes within NPR 7123.1.

The approach used on the CoNNeCT Project to implement each of the 17 common technical processes within NPR 7123.1 is described in the subsequent sections. These processes support the development and analysis of the system architecture, the requirements, the flow down of requirements to the subsystems and the analysis to develop the requirements, develop design concepts, analyze alternative designs, and optimize for the design solution. The interfaces, both internal and external, to the project shall also be defined using these processes. These processes interface with other processes and shall be engaged throughout the lifecycle of the project as changes and modifications occur in order to ensure that the requirements and design are adequate for the realization of the product.

### 5.1.1 Stakeholder Expectation Definition

The stakeholder expectations definition process is used to elicit and define use cases, scenarios, operational concepts, and stakeholder expectations for the CoNNeCT life-cycle phases and WBS model.

#### 5.1.1.1 Level 1 Requirements

The Level 1 requirements provide the top level stakeholder requirements for the CoNNeCT Project. The Level 1 requirements are provided by the NASA SCaN Program Office located at NASA HQ. The Level 1 requirements will undergo a decomposition process conducted by the CoNNeCT team whereby requirements are analyzed for clarity, completeness, and to remove any ambiguous requirements. The final Level 1 requirements are negotiated with the SCaN Program Office and baselined under CoNNeCT Configuration Control. See GRC-CONN-REQ-0019.

#### 5.1.1.2 Science and Technology Requirements

The Science and Technology Requirements Document GRC-CONN-REQ-0031 guides the CoNNeCT project on Level 1 requirements decomposition which provides the project engineering team with the information needed to define the flight payload hardware and ground equipment requirements. The PI specifies in the most fundamental terms possible what is to be measured or controlled and the project engineering team determines how to implement the requirement. The STRD is not a document that will be verified.

#### 5.1.1.3 Operational Concept

The team is responsible for developing the CoNNeCT Operations Concept (OC) and associated documentation. The OC is refined throughout the mission life cycle and is developed in parallel with the architecture and design activities and the requirements flow-down. Changes to the OC that impact requirements must be evaluated for impact prior to implementation.

The specific operations being developed are defined in the CoNNeCT OC document, GRC-CONN-OPS-0026. The concepts in this document cover pre-flight planning and manifesting, as well as on-orbit operations.

#### 5.1.1.4 Technical Requirements Definition

The primary input to the Requirements definition is the baseline Level 1 requirements, GRC-CONN-REQ-0019, and the Science and Technology Requirements, GRC-CONN-REQ-0031, documented during the Stakeholder Expectations Definition Process. Additional inputs to the Requirements Definition and Analysis Process include applicable NASA statutes, regulations, and policies; the intended operational use and utilization environment for the system; ISS carrier design constraints; manufacturing; and ISS attached payload life cycle support considerations.

The output of the Requirements Definition Process is the decomposition of the Level 1 requirements into Level 2 requirements and the technical description of characteristics (Level 3 requirements) the system must have in order to meet Stakeholder Expectations, not a specific solution, which will be evolved in subsequent development processes. This technical description of characteristics for the CoNNeCT system is defined in the CoNNeCT SDR, GRC-CONN-SRD-0013. The CoNNeCT SRD will consist of subsystem performance requirements, payload interface requirements, and safety requirements. The requirements flow down is shown in Figure 5.1.1-1.

## CoNNeCT Requirements and Specification Flow Diagram

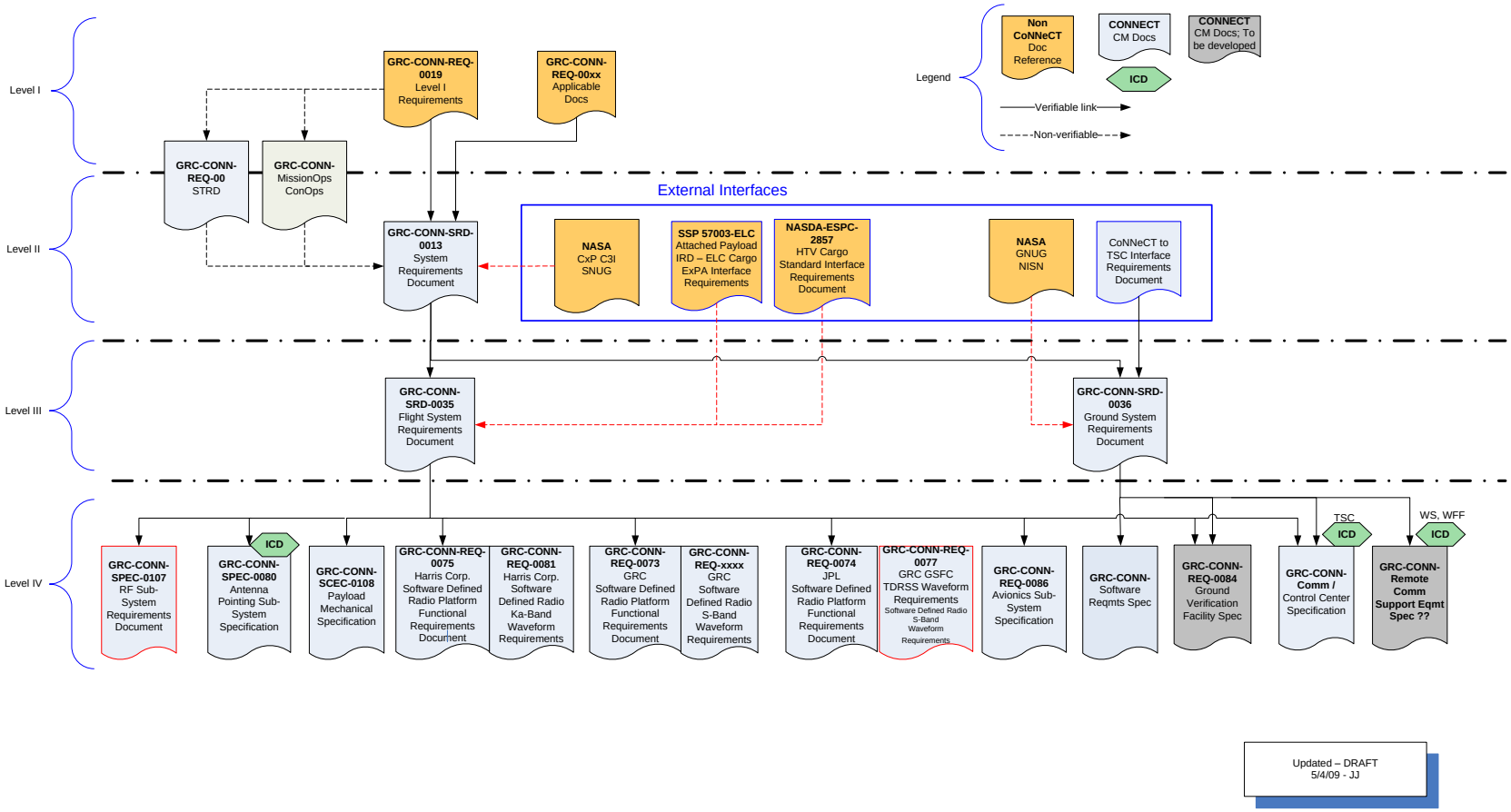


**Figure 5.1.1-1—Requirements Flow Down**

#### 5.1.1.5 Interface Definition

CoNNeCT interface requirements are defined in the ELC to CoNNeCT ICD, SSP 53112 provided by the JSC PIM. The interfaces to the launch vehicle are defined in the HTV to CoNNeCT ICD. Interfaces with the Telescience Support Center and the SN are controlled in CoNNeCT to TSC ICD, GRC-CONN- ICD-0067 and RF ICD with TDRSS and GN, GRC-CONN- ICD-0069, respectively.

### 5.1.2 Logical Decomposition

The logical decomposition process is used to improve understanding of the defined technical requirements and the relationships among the requirements (e.g., functional, behavioral, and temporal) and to transform the defined set of technical requirements into a set of logical decomposition models and their associated set of derived technical requirements for input to the design solution definition process.

### 5.1.3 Design Solution Definition

The second part of the technical solution definition is design solution definition (physical decomposition), which includes definition of the CoNNeCT subsystems, their relationships, and identify the approach that governs their design and evolution over time. This is a repetitive process that involves an analysis of the alternative solutions. Each alternative is evaluated against specific evaluation criteria (technical, safety, cost, and risk), and prioritization/weighting factors are applied to identify the alternative that best fulfills the CoNNeCT mission. The design solution definition process results in multiple sets of the technical requirements to the CoNNeCT subsystem and its components to provide all necessary inputs to the first step of the design realization process – product implementation.

### 5.1.4 Product Realization Process (Physical Solution)

These processes support the effort to fabricate/manufacture and integrate the design into a product. These processes include product implementation and integration, product V&V process and product transition processes. These processes support the development of the technical data package, plans and procedures for system, subsystem test, identification of as-built configurations, identification of test equipment required, facility requirements and documentation of test reports and risk mitigation reports and efforts. These processes and iterations of these processes over the project life cycle will be documented in CoNNeCT Product Assurance Plan, GRC-CONN-PLAN-0006.

### 5.1.5 Design Realization Process

#### 5.1.5.1 Product Implementation

The product implementation process is used to generate a specified product of a WBS model through procurement and fabrication, in a form consistent with the product life-cycle phase exit criteria and that satisfies the design solution definition specified requirements (e.g., drawings, codes, specifications).

#### 5.1.5.1.1 Producibility Analysis

The system/subsystem lead engineers shall identify all producibility issues, which might affect the feasibility of meeting the CoNNeCT requirements. These issues include, but are not limited to, technical performance goals, current state of technology, economic and schedule issues, current skills mix, and facilities availability. This analysis shall be performed as an informal review and may lead to make or buy decisions. All final decisions and the rationale for the decisions will be documented. All hardware fabricated shall comply with all appropriate the GRC fabrication standards.

### 5.1.5.2 Product Integration

The product integration process is used to transform the design solution definition into the desired end product of the WBS model through assembly and integration of lower level validated end products in a form consistent with the product life-cycle phase exit criteria and that satisfies the design solution definition requirements (e.g., drawings, codes, specifications).

## 5.1.6 Evaluation Process

### 5.1.6.1 Product Verification

The product verification process is used to demonstrate that the end product generated from product implementation or product integration conforms to its design solution definition requirements as a function of the product life-cycle phase and the location of the WBS model end product in the system structure.

Definition and development of the requirements verification process will be performed concurrently with the requirements development process. Requirements will be assessed for verifiability and analyzed using one of the following methods: test, analysis, demonstration, similarity, inspection, simulation, validation of records, or not applicable, as described in the SP-6105, NASA Systems Engineering Handbook. Actual design V&V will occur in a planned phased verification program prior to the next higher build.

The CoNNeCT requirements documents include a Design Requirements Verification Matrix. The Design Requirements Verification Matrix will identify each requirement and verification method.

A preliminary version of the Design Requirements Verification Matrix will be required as part of the CoNNeCT PDR.

### 5.1.6.2 Product Validation

The product validation process is used to confirm that the verified end product generated by product implementation or product integration satisfies its intended use when placed in its intended environment and to assure that any anomalies discovered during validation are appropriately resolved prior to delivery of the product. The processes used for validation are described in the V&V Plan (GRC-CONN-PLAN-0012).

#### 5.1.6.3 Product Verification and Validation (V&V) Testing

Each life cycle phase of the CoNNeCT Project will culminate in the performance of validation testing. The tests will also be scheduled and resource loaded on the project schedule. The design verification testing will be conducted as a part of the validation testing wherever possible. When this cannot be accomplished, a separate test procedure will be prepared and executed.

##### 5.1.6.3.1 Testing

Test facilities, systems/subsystems, and equipment shall be conducted in accordance with the CoNNeCT V&V Plan (GRC-CONN-PLAN-0012). Contractor test plans shall be submitted to the CoNNeCT Project for review, approval, and compliance to NASA and CoNNeCT Project test procedures.

##### 5.1.6.3.2 V&V Discrepancy Reporting and Disposition

All discrepancies identified during the V&V testing shall be corrected as part of the V&V process with all dispositions being documented in the appropriate documentation. During V&V, discrepancies of all kinds need to be noted and documented. Rework or retest may be required. In the extreme case, redesign may be required. The type of discrepancy will then drive the required project documentation.

The GRC Corrective and Preventive Action Reporting System (CPARS) discrepancy tracking system will be used to document the problem description and track it to closure. The CPARS system is described in the CoNNeCT Product Assurance Plan, GRC-CONN-PLAN-0006. The CoNNeCT S&MA representative will manage the CPARS tracking system. The CPARS manager will categorize the discrepancy and present critical reports to the CCB and subsequently route the remaining lower level discrepancies to the appropriate subsystems lead. The CPARS manager will report the status of the discrepancy to the CoNNeCT PM on a regular basis. Any uncorrected discrepancies will be documented in the appropriate reporting format (e.g., deviation, waiver, exception, etc.). .

### 5.1.7 Product Transition Process

The transition process will result in products delivered to the appropriate destinations, in the required condition for operation by the user, and for the appropriate training of installers, operators, or maintainers.

The current CoNNeCT task has the CoNNeCT flight design as the end product to be delivered to the ISS for initial check-out.

## 5.2 Technical Management Processes

### 5.2.1 Tech Planning

Technical planning starts with the product line life cycle definition as directed by the NASA NPR 7120.5, Program and Project Management Processes and Requirements.

The CoNNeCT subsystem as a flight system shall follow the four-part PM process as defined in Chapter 3 of NPR 7120.5, going though Formulation, Implementation, Approval, and Evaluation Phases. The approval process is an ongoing effort to be implemented by the senior NASA management to determine at key project reviews (refer to Section 3.4.1 of this document) that the project is ready to continue with formulation, or to proceed to or continue with implementation.

The technical planning is required to plan and manage each of the common technical processes applicable to the CoNNeCT Project and described in previous sections.

### 5.2.2 Requirements Management

The CoNNeCT Project will utilize the Telelogic Dynamic Object-Oriented Requirements System (DOORS)®, as the project requirements management tool, to capture, link, trace, analyze and manage changes to information to ensure the project's compliance to specified requirements and standards from the requirements definition and analysis process through the V&V process. All CoNNeCT team members, whether onsite or off, will be able to access requirements via DOORSNet, a web-enabled feature of DOORS®.

For PDR, the complete requirements set will not be in DOORS; specifically, the Level 4 requirements specifications will not be in the database. Prior to CDR, all requirements documents will be in the database.

#### 5.2.2.1 Requirements Traceability

Requirements traceability and rationale will be documented for each requirement contained in project specifications. Traceability and compliance are documented in a field directly tied to each requirement. The CoNNeCT Project will use DOORS® to ensure traceability is performed. The DOORS® tool also allows visibility into the requirements allocation, compliance, and verification. The project will maintain a central server where all CoNNeCT-generated requirements documents are controlled and the ISS-sourced requirements document are included.

Identification of requirement sources is performed as part of the requirements development process. The CoNNeCT SRD, GRC-CONN-SRD-0013, trace to the ELC to CoNNeCT ICD. All CoNNeCT systems requirements will have their traceability documented, either to a direct higher level requirement for requirements flowing directly, or to the document showing how that requirement was derived for all derived requirements. Where the derivation may be simply and clearly explained, the derivation explanation may also be placed directly in the specification.

The SE is responsible for identifying requirement sources for requirements contained in the CoNNeCT SRD. System and lower level allocated requirements are used as the basis for generating subsystem, ground handling, and assembly and component requirements. The subsystem leads are responsible for identifying traceability to the system requirements during requirements generation for their lower level elements.

#### 5.2.2.2 Interface Management

The CoNNeCT design team, along with SE, shall determine when formal ICDs are required.

#### 5.2.2.2.1 CoNNeCT ICDs

The CoNNeCT Project will develop ICDs with the following sub-systems and meta-systems:

- GD, Harris, JPL radio partners
- HTV Launch Vehicle
- International Space Station (ISS)
- White Sands and Wallops Facility Stations
- JPL RF subsystem
- Telescience Support Center
- RF (Space Network)

#### 5.2.2.2.2 Interfaces and ICDs

Technical control of interfaces, including identification and analysis, ownership designation, documentation, change control, and verification are mandatory to ensure a consistent and integrated system design. The responsibility for performing this function is shared jointly between systems engineering and all subsystem teams, with systems engineering having responsibility for system level and external interfaces, and the subsystems teams having responsibility for their internal interfaces with other subsystems.

Interfaces are developed, defined and controlled through the use of the ICD and Interface Control Drawings. Once external or internal interfaces have been established and baselined, CoNNeCT CM will control changes via the appropriate CM change process.

### 5.2.3 Technical Risk Management

The CoNNeCT Project will be developed under the proto-flight approach and shall implement continuous risk management to insure project risks are addressed. The continuous risk management shall be developed during the formulation stage, documented in the CoNNeCT Risk Management Plan (GRC-CONN-PLAN-0007), and executed/maintained throughout the life of the project. The objective of the Risk Management Plan is to document the process in which the CoNNeCT team will identify and assess the risks in achieving project success, and to balance the mitigation of these risks against the acceptance and control of these risks. The CoNNeCT Risk Review Panel will review and develop strategies for mitigating CoNNeCT risks (See Appendix D for charter for Risk Review Panel). The GRC Risk Management Office will appoint a risk management lead to develop the Risk Management Plan, conduct risk training, and help identify risks, oversee risk management activities.

### 5.2.4 Configuration Management (CM)

The CoNNeCT Configuration Manager shall implement a CM system for the control of all configuration, documentation, physical media, and physical parts representing or comprising the CoNNeCT system in accordance with Glenn Procedural Requirements GLPR 8040.1. The CoNNeCT CM Plan is documented in GRC-CONN-PLAN-0002.

The CM Manager responsibilities include:

- Baseline management
- Preparation of change control status reports
- Member of the configuration change control board (secretariat)
- Participation in formal design reviews
- Management of the configuration library and database(s)

For software, a configuration plan shall be developed per the software class designated by the CoNNeCT software engineering lead. The CoNNeCT software CM and data management plan is documented in GRC-CONN-PLAN-0001.

#### 5.2.4.1 Change Control Procedures

Change control procedures will be established by the CoNNeCT CM team with the intent of controlling changes to baselined project technical requirements and documentation. Once system/subsystem requirements have been baselined, all new requirements will be submitted to the CCB for assessment and approval. Upon approval, the baseline will be changed to reflect new requirements. Lower level boards can be established to address lower level requirements and documentation, if required.

##### 5.2.4.1.1 CoNNeCT Control Board (CCB)

The project has a CCB whose purpose is to be a decision-making body which approves and controls the baseline of the project. The CCB also performs such functions as CM and control, evaluates key technical issues, and makes recommendations on other project significant matters requiring decisions to the PM. The project CM lead will facilitate the CCB in the CM of project controlled baselines. The CCB is the formal project decision-making body and will be chaired by the PM and, as a minimum, have as members the project CE, the Principle Investigator (PI), and the S&MA Lead. The CE determines the technical expertise required and nominally the CCB includes the LSE, Software Lead, and other engineers relevant to the CCB content under review. The PM, or his designee, is the final authority for all decisions for the CCB. The DPM may serve as the alternate chair per the discretion and the request of the PM. The DR and the CM lead are also members but non-voting. Additional members can be added to the CCB as needed depending on the subject matter the CCB is addressing.

##### 5.2.4.1.2 Change Approval Procedure

The CoNNeCT cognizant team member(s) who holds principal responsibility for a system/subsystem will submit the change documentation to the CCB. On receipt of the change documentation, the CCB shall consider the proposed changes, taking into consideration the economic impact upon the project, as well as the technical merits of the proposed changes. Approval of the proposed change documentation shall require the signature of the CCB Chair. Final approved documents shall be disseminated to the project team and retained in the project archives**.** The CCB shall have an action-tracking log for ensuring completion.

### 5.2.5 Technical Data Management

The Technical Data Management Plan will be documented in the CoNNeCT CM Plan, GRC-CONN-PLN-0002, and include the use of a control and documentation database for all technical data and technical related correspondence. This will ensure that all data will be tracked and referenced.

#### 5.2.5.1 Technical Data Security

The CoNNeCT Project Plan will define Information Technology (IT) security requirements for the project. These include administration and operational risks to the project and any products. The project has generated an export control memo to define requirements for transmitting ITAR and SBU information. The extent of security measures to counter risk will depend upon the overall sensitivity of the data produced by the project.

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### 5.2.6 Technical Assessment

The technical assessment process is used to help monitor progress of the technical effort, including contracted efforts, and provide status information for support of the CoNNeCT system design, product realization, and technical management processes.

System performance measures provide preliminary information about the ability of the system to meet the user's expectations. The intent of implementing performance measurement activities is to provide the CoNNeCT project and SCaN customer insight into progress toward the definition and development of the technical solution, a continuous evaluation of the risks and issues associated with the technical solution, and the probability the technical solution will meet the objectives of the customer. The measurements provide additional data to evaluate issues that impact project cost, schedule, and technical (performance, functionality, and quality) objectives to make better informed programmatic decisions.

Measures of Effectiveness (MOE) are the operational measures of success developed against any potential design solution. They represent the stakeholder's perspective and validate how well the solution achieves its intended purpose to meet mission or operational objectives in the environment under a specified set of conditions. MOEs refer to the stakeholders intentions.

Measures of Performance (MOP) measure physical or functional attributes of the design solution deemed important to ensure the system has the capability to achieve operational objectives. MOPs are quantitative and used to assess how well the system design meets the design or performance requirements that satisfy the MOEs. MOPs refer to the actual performance of the system.

Technical Performance Measures (TPM) are quantitative assessments of critical technical parameters (system element attributes) which are used to confirm progress and project monitors to ensure that the technical objects of the project will realized. TPMs typically have planned values at defined time increments, against which estimated and actual values are plotted.

The CoNNeCT Project developed a set of performance measures to support the design development of the SCaN Testbed. Several technical performance measurements were identified by the SE&I team to track and control resources. As discipline engineers realize changes to specific system attributes previously documented in configuration managed reports and analysis, the changes necessary to update the documents are brought forward to the ERB for approval.

A primary objective of the stakeholder is that the SCaN Testbed support experiment and demonstrations from the ELC on the ISS. Installation approval must be granted by the ISS community. The milestones set forth in the process by ISS must be met and in a timely manner. This is identified as the first MOE in Table 5.2.6.1-1. The supporting MOP requires the project to identify and verify compliance to the ISS requirements. These requirements are identified as TPMs and tracked through the project.

**Table 5.2.6—Measures of Effectiveness for ISS**

| Type | Item | Threshold | Indicator |
|---|---|---|---|
| TPM | Mass | Flight System mass max 500lbs | Track Flight System component Mass - trend over time |
| TPM | Envelope | Max HTV and ELC on-orbit envelope dimensions: X - 46", y - 45", Z - 34" | Flight System envelope dimensions - trend over time |
| TPM | CG | Equal to or less than ExPA CG X/Y-CG +/- 7.5" and Z CG 19.5" | System is within planned ExPA X/Y/Z CG envelops - trend over time |
| TPM | Thermal Margins | Per component as identified in the Thermal Analysis Report | System operating/non-operating actual vs. analysis temperatures - trend over time |
| TPM | Power Budget | Steady State Power maximum 500W | Estimated and actual power usage of system - trend over time |

Another primary objective identified as an MOE are the data rates required to support the on-orbit experiments and demonstrations. The correlating MOP from the CoNNeCT Project was the identification of the total amount of data the SCaN Testbed would be required to support. The TPMs are the system attributes that were identified to support the data rates for the estimated time the system would be supporting those data rates.

**Table 5.2.6-2—Measure of Effectiveness for Data Rates**

| Type | Item | Threshold | Indicator |
|---|---|---|---|
| MOE | Conduct Test and Demonstration Experiments - Data Rates | Ka-band Fwd at least 6Mbps<br>Ka-band Rtn at least 100Mbps<br>S-band Fwd at least 72kbps<br>S-band Rtn at least 192kbps | Data Rates - trend over time |
| MOP | Ka-band and S-band operations | 60 S-band Medium Data Rate contacts of 20 minutes per month<br>100 High Data Rate contacts of 35 minutes per month | # of contacts - trend over time |
| TPM | Processor Utilization | Min of 30% processor available for experimenters. | % of processor utilization - trend over time |

### 5.2.7 Decision Analysis

Trade study is the first process which is conducted to decide among design alternatives and their related manufacturing, testing, and support processes; program schedules; and lifecycle cost. Trade studies are made at the appropriate level of detail to support decision making and lead to a proper balance between system performance and cost.

Requirements come from many sources and unfortunately can conflict with each other. Trade studies are used for the resolution of these conflicts.

A second forum includes the CoNNeCT ERB described in Appendix D. This board reviews issues, solves problems, and evaluates changes within its scope of authority. This board makes programmatic recommendations to the CCB that is the decision authority at the project level. The CCB is described in the Project Plan.

# 6.0 TECHNOLOGY INSERTION

The technology elements of CoNNeCT include the pre-flight development of the communication subsystem to TRL of 6. Pre-flight, this subsystem is verified to be compliant to a single SDR architecture standard, the Space Telecommunications Radio System (STRS). The key elements of this subsystem are the SDR's and the Radio Frequency (RF) subsystem. The Experiment Communication Systems Lead is responsible for defining requirements and conducting assessments to verify TRL-6 has been achieved.

The SDR technology advancement of each SDR resides in the reconfigurable nature of the digital electronics, consisting of one or more reprogrammable field programmable gate arrays (FPGAs) and associated general purpose processors. The FPGAs allow the SDRs to operate at higher data rates and run more complex algorithms than with general-purpose processors alone. The FPGAs also consume less power than the processors, providing more capability at less power. The capability of the payload allows these processors and FPGA to be reprogrammed in flight. Along with the digital portion, the SDR also have RF capability. The SDRs operate full duplex from user data through standard baseband interfaces to the RF interface of S-band, Ka-band, and receive L-band (GPS) frequencies.

Lesson learned during the course of the program/project will be documented to promote advanced technology solutions and new product innovations as applicable.

The following is excerpted from the CoNNeCT Level 1 Requirements Document:

This ISS testbed will provide an adaptable orbiting test and demonstration environment for space communications, navigation and networking devices including SDRs, transmitters, receivers, antennas, network interfaces, and other peripheral devices required for complete space communication systems. CONNECT will enable: 1) on-orbit experiments to support on-going development of the STRS standard; 2) advance communications, navigation and networking technologies; 3) enable future mission capabilities; and 4) reduce programmatic, development and operational risks of future missions.

The CONNECT Project will provide NASA, industry, other Government agencies, and academic partners the opportunity to develop and field communications, navigation, and networking technologies in the laboratory and space environment based on re-Configurable, software defined radio platforms and the STRS architecture.

# 7.0 ADDITIONAL SE FUNCTIONS AND ACTIVITIES

This section of the SEMP describes the process of how the various inputs into the SE effort will be integrated and how multidisciplinary teaming will be implemented to integrate appropriate disciplines into a coordinated SE effort that meets cost, schedule, and performance objectives of the CoNNeCT Project.

## 7.1 Safety, Security, and Mission Assurance

Because of the multiple interfaces, requirements, customers, and project phases, the CoNNeCT Project shall have a separate Product Assurance Plan that describes all the S&MA activities and documentation in an integrated fashion. It will address the following project S&MA programs:

- System Safety
- Materials and Process
- Reliability/Maintainability
- Quality
- Software Quality Assurance

Various S&MA activities shall be performed during all project phases from concept to disposal. During the concept and design phase, GRC S&MA requirements and best practices will be identified and incorporated into the design as part of the normal design review process. Sources for these requirements and best practices include NASA documents, NASA lessons learned system, and federal and state regulations such as OSHA. The primary analyses that shall be accomplished during the project design are: called System Assurance Analyses (SAA). These analyses shall be performed for each major CoNNeCT subsystem and include the following as a minimum:

- Failure Modes and Effects Analysis
- Hazard analysis
- Reliability analysis - failure modes and effects analyses/critical items list (FMEA/CIL) on critical subsystems
- Fault tree analysis
- Sneak circuit, quantitative reliability, maintainability, Electrical, Electromechanical and Electromagnetic (EEE) parts selection, human factors, or special analyses as required by the CCB
- Recommendations for improvement

The primary goal of the analyses is to enhance design iteratively to eliminate hazards and single failure points that have loss of life, loss of or damage to critical ground systems and equipment, and personnel injury potential. Safety hazards will be identified and addressed through the phased safety reviews. Where single failure points (critical items) cannot be eliminated, CIL sheets shall be generated and approved by GRC S&MA Office. Each designer shall be responsible for incorporating safety, reliability, maintainability, and quality considerations into their design. The GRC S&MA design issues shall be addressed and resolved during design reviews. Where resolution is not achieved, S&MA issues will be brought to the CoNNeCT CCB for resolution.

While considered during design, the primary safety concerns associated with this project during construction, activation, operations, and maintenance will include those that pertain to compliance with OSHA, EPA, or other federal or state regulations. Use of appropriate S&MA practices and adherence to generic industrial safety requirements will be followed on this project.

The quality program shall be tailored for the various missions of the CoNNeCT Project using the GRC S&MA programs directive. As a minimum, the quality program shall consist of inspections, testing, and analysis of systems and equipment hardware and software designed, fabricated, operated, and processed at the GRC to ensure the desired level of quality is maintained.

### 7.1.1 Lessons Learned

The CoNNeCT project captures and applies lessons learned in accordance with NPR 7120.6 *Lessons Learned* Process, in several ways. The GRC S&MA Office has an ongoing lessons learned program. The purpose of this program is to reduce the number of mishaps, incidents, and close calls related to ground and flight testing of the GRC projects. Lessons learned collected by the GRC S&MA Office are also entered into the NASA LLIS, which are used to assist other Center programs in using lessons learned.

## 7.2 Systems Engineering Tools

During the course of the CoNNeCT Project, various types of analysis will be performed. Due to the large market of tools available to aid in analysis efforts, the project team must come to consensus on certain types of tools to be used. This uniformity will ensure compatibility between the files that would be shared among team members, thereby minimizing loss of productivity. Other tools shall be added as needed throughout the life cycle of this project. Software CM shall be addressed in computer software. Current tools to be applied to the CoNNeCT Project are as follows in Table 7.2-1:

**Table 7.2-1—Software Tools**

| Product | Tool |
|---|---|
| Collaboration | eRoom |
| Schedule | Project, CASE |
| Spending Plan | Microsoft Excel |
| Requirements Document | Microsoft Word, DOORS |
| Requirements Verification Matrix | Excel, DOORS |
| Requirements Management | Telelogic DOORS |
| Drawings/Models | PTC Pro Engineer |
| Defects | CPARS |
| Engineering Analysis | Nastran |
| | SINDA |
| | Microsoft Excel |
| Risks | Rmit |
| Presentations | Microsoft PowerPoint |
| Plans and Procedures | Microsoft Word |
| PDM/CM | PTC Windchill |
| Configuration Management | eRoom |
| | Bloodhound |
| | Windchill |
| Software Configuration | Subversion |
| | Subversion |
| Reliability Analysis | PRISM, Raptor |
| Fault Tree Analysis | SAPHIRE |

If any tools are developed by the CoNNeCT Project, they will be documented and controlled under the GRC software CM tool policy.

## 7.3 Specialty Engineering

The need for specialty engineering expertise will be related to technical risks and projected use of the technology being selected. These efforts will center on system development for technology experiments and the need for specialty assurance engineering will be assessed on a case-by-case basis. The resources to perform these analyses will be provided to the GRC Project Office by team members or through contracted specialists.

Specialty engineering ensures the CoNNeCT Project technology development and systems designs are compatible with the interface needs and expected operating environment, and utilizes resident expertise and specialty engineering knowledge from past and current GRC projects.

### 7.3.1 Risk Engineer

CoNNeCT will prepare a formal Risk Management Plan. When using a commercial off-the-shelf (COTS) component, CoNNeCT will attempt to procure the optimal reliability component. The selection will be based on the following:

1. Acceptable vendor screening program to the project requirements (burn-in, thermal cycle and vibration levels)
2. Acceptable vendor quality control program
3. A Mean-Time Between Failure (MTBF) which supports the system reliability allocation
4. Radiation hardness and minimized EMI susceptibility, as needed.

### 7.3.2 Safety Engineer

The systems safety engineer (SSE) will analyze the effect of the CoNNeCT Project technology for hazards and safety issues.

Initially, a preliminary hazard analysis (PHA) will be performed early in the system design to determine the potential hazards that may occur as a result of the system or subsystems involved. The Safety Engineer will review all parts of the design, especially the Ka-band transmissions, to identify hazards and he will document them in the Safety Data Package. Hazards analysis is part of the design process and used in every phase of the design.

# 8.0 INTEGRATION WITH PROJECT PLAN

## 8.1 Role and Responsibilities of Project Management

The CoNNeCT PM will have total life cycle management responsibility for the CoNNeCT systems. This will include management responsibilities for integration, modification, production, V&V, risk management, training and support. As such, the manager exercises programmatic, technical, and financial control of the project.

The CoNNeCT PM reports programmatically SOMD at HQ. She also reports status to Code M organizations at the GRC. Program direction and budget negotiations for CoNNeCT are worked through SOMD at NASA HQ.

The CoNNeCT PM will coordinate with the LSE at the GRC who will provide guidance and oversight to ensure that systems engineering policies and standards followed.

## 8.2 Authorities, Responsibilities and Integration across Government and Contractor Boundaries

Integration of Government and contractor products will be coordinated by CoNNeCT Project management and approved through the CoNNeCT CCB. The established control boards will be responsible for reviewing, guiding, and integrating the NASA and contractor technical work and products associated with the CoNNeCT flight and ground systems. See Appendix D for review board charters for CoNNeCT.

# 9.0 WAIVERS

Deviations and waivers will be processed in accordance with GLPR 7120.5.20. For Level III and lower requirements, the GRC Director of Engineering delegated signature authority to the Project Chief Engineer.

# APPENDIX A PROJECT REVIEWS AND EXPECTATIONS

**Table 1—PDR Entrance Criteria from NPR 7123.1**

| PDR Entrance Criteria | Project Evidence |
|---|---|
| Successful completion of the CONNECT SRR and responses made to all SRR RIDs, or a timely closure plan exists for those remaining open. | Evidence will show all SRR RIDs are closed. |
| A preliminary PDR agenda, success criteria and charge to the board have been agreed to by the technical team, project manager, and review chair prior to the PDR. | These items will be contained in the formal PDR plan and the plan briefed to the Standing Review Board, thereby satisfying the entrance criterion. |
| PDR technical products listed below for both hardware and software system elements have been made available to the cognizant participants prior to the review: | NA |
| Updated baselined documentation, as required. | The Configuration Management Plan, Systems Engineering Management Plan, Risk Management Plan, Systems Requirements Document, Flight Systems Requirements Document and Project Plan will be updated. |
| Preliminary project design specifications for each configuration item (hardware and software), with supporting trade-off analyses and data, as required. The preliminary software design specification should include a completed definition of the software architecture and a preliminary database design description, as applicable. | Each hardware item (radios, avionics, etc) will have a specification. See PDR plan for the detailed list. The Software Requirements Specification will also be reviewable. |
| Updated technology development maturity assessment plan. | This information on technology assessment will be contained in the project plan. |
| Updated risk assessment and mitigation. | The project level risks, SE&I, MO, S&MA and Payload Risks will be documented. |
| Updated cost and schedule data. | Project cost and integrated master schedule will be available. An independent cost assessment report will be documented. |
| Updated logistics documentation, as required. | A system level logistics plan will be reviewable. |
| Applicable technical plans (e.g., technical performance measurement plan, contamination control plan, parts management plan, environments control plan, EMI/EMC control plan, payload-to-carrier integration plan, producibility/manufacturability program plan, reliability program plan, quality assurance plan). | Project plans and technical plans will be provided and will be specified in the PDR Plan. |
| Applicable standards. | Applicable NASA standards will be defined. |

| **PDR Entrance Criteria** | **Project Evidence** |
|---|---|
| Safety analyses and plans. | Phase 0/1 Safety data Package |
| Engineering drawing tree. | A drawing tree will be reviewable. |
| Interface control documents | Interface Control Documents will be provided for the carrier, launch vehicle. Each radio and the RF Subsystem will have an Interface Control Document |
| V&V plan | A Master V&V Plan will be reviewable. Verification methods will be documented in the system level requirements documents. |
| Plans to respond to regulatory requirements (e.g., Environmental Impact Statement), as required. | Telecommunications and Information Administration spectrum permit, Export Control memo for ITAR will be reviewable |
| Disposal plan. | A Disposal Plan will be reviewable. |
| Technical resource utilization estimates and margins. | Data showing mass, volume, power and link budgets will be available. |
| System level safety analysis | A system level safety analysis, consisting of the Safety data Package and Failure Modes and Effects Analysis will be reviewable. |
| Preliminary limited life list (LLL). | A Limited Life List will be reviewable as part of the Product Assurance Plan. |

## Table 2—CONNECT PDR Success Criteria and Evidence

| 7123 Review Source | NPR 7123.1 PDR Success Criteria | |
|---|---|---|
| | **Success Criteria** | **Project Expectations** |
| PDR | 1) The top-level requirements—including mission success criteria, TPMs, and any sponsor-imposed constraints—are agreed upon, finalized, stated clearly, and consistent with the preliminary design. | The CoNNeCT Level 1 requirements will be complete and traceable to the System Requirements Document. The top-level Operations Concept is defined, and a draft of a more detailed Concept of Operations Document is available. Fully successful and minimum success criteria will be identified. Technical performance measures will be identified. |
| PDR | 2) The flow down of verifiable requirements is complete and proper or, if not, an adequate plan exists for timely resolution of open items. Requirements are traceable to mission goals and objectives. | Requirements decomposition of the Level I requirements down to Level IV will be completed. Complete functional decomposition from the Con Ops (including Mission Ops) into requirements will not be performed for this review. Basic operational capability and modes of operation will be identified, defined and decomposed. |
| PDR | 3) The preliminary design is expected to meet the requirements at an acceptable level of risk. | The risk list and mitigations will be available to assess the project's risks. |
| PDR | Definition of the technical interfaces is consistent with the overall technical maturity and provides an acceptable level of risk. | Interface Control Documents will be provided for the carrier, launch vehicle, SN and GN. Each radio and the RF Subsystem will have an Interface Control Document. |
| PDR | Adequate technical interfaces are consistent with the overall technical maturity and provide an acceptable level of risk. | Interface Control Documents will be provided for the carrier, launch vehicle, SN and GN. Each radio and the RF Subsystem will have an Interface Control Document. |
| PDR | Adequate technical margins exist with respect to TPMs | System level power and mass margins will be stated. A mass properties report will be reviewable. |
| PDR | Any required new technology has been developed to an adequate state of readiness, or back-up options exist and are supported to make them a viable alternative. | The CoNNeCT is a technology experiment. Except for the radios and waveforms themselves, there is no technology development required. |
| PDR | The project risks are understood and have been credibly assessed, and plans, a process, and resources exist to effectively manage them. | The project level risks, SE&I, Mission Operations, Safety and Mission Assurance and Payload Risks will be documented. The project's risk process will be described. |

| **7123 Review Source** | **NPR 7123.1 PDR Success Criteria** | |
|---|---|---|
| | **Success Criteria** | **Project Expectations** |
| PDR | Safety and mission assurance (e.g., safety, reliability, maintainability, quality, and EEE parts) have been adequately addressed in preliminary designs and any applicable S&MA products (e.g., PRA, system safety analysis and failure modes and effects analysis) have been approved. | System level safety and mission assurance plans and reports will be documented. |
| PDR | The operational concept is technically sound, includes (where appropriate) human factors, and includes the flow down of requirements for its execution. | The top-level Operations Concept is defined, and a draft of a more detailed Concept of Operations Document is available. The operational scenarios will be defined. |

## CoNNeCT Interpretation and Implementation of the PDR Success Criteria

| Category | Success Criteria |
|---|---|
| **Review Process** | The SRR was successfully completed, and responses made to each Review Item Discrepancy (RID). All subsystem PDRs, or equivalents, have been successfully completed. All assigned actions have an acceptable disposition including plans to complete for work in process. |
| **Technical Management** | All processes (design, implementation, interface controls, risk management, safety, test & verification, operations, etc.) used to develop and operate the system are at expected maturity level. The preliminary design is expected to meet the requirements within the resource allocation or adequate plans exist for timely resolution of open items. |
| **System Design and Demonstration** | The preliminary design is consistent with the top-level requirements or adequate plans exist for timely resolution of open items. The operations concept, if applicable, is technically sound or adequate plans exists for timely resolution of open items. The defined technical interfaces are consistent with the overall technical maturity. Adequate margins exist with respect to technical performance or adequate plans exist for timely resolution of open items. Any required new technology has been developed to an adequate state of readiness or viable options exist. |
| **Safety & Mission Assurance** | Safety, reliability, maintainability, quality, and Electrical, Electronic and Electromechanical (EEE) parts have been adequately addressed in preliminary designs and any applicable S&MA products (i.e., hazard analysis and failure modes and effects analysis) have been identified. |
| **Project Management** | Design definition is sufficient to support initial parametric and bottoms-up cost estimating. Cost estimates, control processes, and schedule indicate the system will be ready on time (i.e., integration, delivery, launch, etc.) and within budget or adequate plans exist for timely resolution of open items. |
| **Risk Management** | The project risks are understood and have been credibly assessed, and plans, processes, and resources exist to effectively manage them or adequate plans exist for timely resolution of open items. |

**Table 3—Software Architecture Review Entrance Criteria**

| | PDR Entrance Criteria | Project Evidence |
|---|---|---|
| SWAR | Successful completion of the CONNECT SW SRR and responses made to all SRR RIDs, or a timely closure plan exists for those remaining open. | Evidence will show all software SW SRR RIDs are closed. |
| SWAR | A preliminary agenda, success criteria, and charge to the board have been agreed to by the technical team, project manager, and review chair prior to the PDR. | These items will be contained in the software PDR plan, thereby satisfying the entrance criterion. |
| SWAR | Technical products listed below for software system elements have been made available to the cognizant participants prior to the review. | NA |
| SWAR | Updated baselined documentation, as required. | The Software Configuration Management Plan will be updated. |
| SWAR | Preliminary project design specifications for each configuration item (hardware and software), with supporting trade-off analyses and data, as required. The preliminary software design specification should include a completed definition of the software architecture and a preliminary database design description, as applicable. | The Software Requirements Specification will also be reviewable. |
| SWAR | Updated risk assessment and mitigation. | The software WBS risks will be documented. |
| SWAR | Updated cost and schedule data. | Software cost and integrated master schedule will be available |
| SWAR | Updated logistics documentation, as required. | Not Applicable |
| SWAR | Applicable technical plans (e.g., technical performance measurement plan, contamination control plan, parts management plan, environments control plan, EMI/EMC control plan, payload-to-carrier integration plan, producibility/manufacturability program plan, reliability program plan, quality assurance plan). | Contamination Control Plan, Product Assurance Plan, EMC Control Plan, Assembly and Integration Plan. |
| SWAR | Applicable standards. | Liste in the Systems Requirements Document |
| SWAR | Safety analyses and plans. | Not Applicable |
| SWAR | Engineering drawing tree. | Not Applicable |
| SWAR | Interface control documents | Not Applicable |
| SWAR | Verification/validation plan. | A Software V&V Plan will be reviewable. |

| | **PDR Entrance Criteria** | **Project Evidence** |
|---|---|---|
| SWAR | Plans to respond to regulatory requirements (e.g., Environmental Impact Statement), as required. | Not Applicable |
| SWAR | Disposal plan | Not Applicable |
| SWAR | Technical resource utilization estimates and margins. | Data showing resources, phasing plans, budget and schedule for software will be reviewable. |
| SWAR | System-level safety analysis | Not Applicable |
| SWAR | Preliminary limited life list (LLL | Not Applicable |

**Table 4—CONNECT Software Architecture Review Success Criteria and Evidence**

| **7123 Review Source** | **NPR 7123.1 SWAR Success Criteria** | |
|---|---|---|
| | **Success Criteria** | **Project Expectations** |
| SWAR | 1)The top-level requirements—including mission success criteria, TPMs, and any sponsor-imposed constraints—are agreed upon, finalized, stated clearly, and consistent with the preliminary design. | The CoNNeCT Level 1 requirements will be complete and traceable to the System Requirements Document. The top-level Operations Concept is defined, and a draft of a more detailed Concept of Operations Document is available. Fully successful and minimum success criteria will be identified. Software Specification will be complete. |
| SWAR | 2) The flow down of verifiable requirements is complete and proper or, if not, an adequate plan exists for timely resolution of open items. Requirements are traceable to mission goals and objectives. | The project will demonstrate the flow down of requirements from the Level 1 requirements, safety and Science and Technology Requirements Document to the Flight System Requirements Document, the Ground System Requirements Document and the lower level Software documents. |
| SWAR | 3) The preliminary design is expected to meet the requirements at an acceptable level of risk. | A Compliance Matrix will be available indicating which Science and Technology Requirements and which Level 1 requirements will be met and which will not, be met, if any. |
| SWAR | Definition of the technical interfaces is consistent with the overall technical maturity and provides an acceptable level of risk. | NA |
| SWAR | Adequate technical interfaces are consistent with the overall technical maturity and provide an acceptable level of risk. | NA |

| **7123 Review Source** | **NPR 7123.1 SWAR Success Criteria** | |
|---|---|---|
| | **Success Criteria** | **Project Expectations** |
| SWAR | Adequate technical margins exist with respect to TPMs. | NA |
| SWAR | Any required new technology has been developed to an adequate state of readiness, or back-up options exist and are supported to make them a viable alternative. | The CoNNeCT is a technology experiment. Except for the radios and waveforms themselves, there is no technology development required. |
| SWAR | The project risks are understood and have been credibly assessed, and plans, a process, and resources exist to effectively manage them. | The software risks will be documented. |
| SWAR | Safety and mission assurance (e.g., safety, reliability, maintainability, quality, and EEE parts) have been adequately addressed in preliminary designs and any applicable S&MA products (e.g., PRA, system safety analysis, and failure modes and effects analysis) have been approved. | Not Applicable |
| SWAR | The operational concept is technically sound, includes (where appropriate) human factors, and includes the flow down of requirements for its execution. | The top-level Operations Concept is defined, and a draft of a more detailed Concept of Operations Document will be available. The operational scenarios will be defined. |

**Table 5—CDR Entrance Criteria from NPR 7123.1**

| | | |
|---|---|---|
| CDR | 1. Successful completion of the PDR and responses made to all PDR RFAs and RIDs, or a timely closure plan exists for those remaining open. | Evidence will show all PDR RIDs are closed. |
| CDR | 2. A preliminary CDR agenda, success criteria, and charge to the board have been agreed to by the technical team, project manager, and review chair prior to the CDR | These items will be contained in the formal CDR plan, thereby satisfying this entrance criterion. |
| CDR | CDR technical work listed below for both hardware and software system elements have been made available to the cognizant participants prior to the review: | (Heading Row) |
| CDR | updated baselined documents, as required; | The Configuration Management Plan, Risk Management Plan and Project Plan will be updated. |
| CDR | product build-to specifications for each hardware and software configuration item, along with supporting trade-off analyses and data. | Each hardware item (radios, Gimbal, etc) will have a build-to specification. See CDR plan for the detailed list. |
| CDR | fabrication, assembly, integration, and test plans and procedures; | An Assembly and Integration plan will be complete. Test plans and some test procedures will be complete. |
| CDR | technical data package (e.g., integrated schematics, spares provisioning list, interface control documents, engineering analyses, and specifications); | Ninety percent of the drawings and schematics will be complete. The ICDs, sparing list, specifications and analyses will be complete (see the CDR plan for the document list). |
| CDR | operational limits and constraints; | |
| CDR | technical resource utilization estimates and margins; | Data showing resources, phasing plans, budget and schedule will be reviewable. |
| CDR | acceptance criteria; | Acceptance Criteria. |
| CDR | command and telemetry list; | A command and Telemetry list will be complete. |
| CDR | verification plan (including requirements and specification); | The V&V Plan will be reviewable. |
| CDR | validation plan; | The V&V Plan will be reviewable. |
| CDR | launch site operations; | Launch site activities will be identified. |
| CDR | checkout and activation plan | The on-orbit checkout and activation plan will be complete. |
| CDR | disposal plan (including decommissioning or termination); | A Disposal Plan will be reviewable. |
| CDR | updated Technology Development Maturity Assessment Plan | The CoNNeCT is a technology experiment. Except for the radios and waveforms |

| | | |
|---|---|---|
| | | themselves, there is no technology development required. |
| CDR | updated risk assessment and mitigation; | The project level risks, SE&I, MO, S&MA and Payload Risks will be documented. |
| CDR | updated reliability analyses and assessments | System level safety and mission assurance plans and reports will be documented. |
| CDR | updated cost and schedule data; | Cost and Schedule |
| CDR | updated logistics documentation; | Logistics documentation will be complete, including shipping plans facility plans and checkout. |
| CDR | software design document(s) (including interface design documents); | Software products will be available. |
| CDR | updated LLIL; | This list will be contained in the Product Assurance Plan. |
| CDR | subsystem-level and preliminary operations safety analyses; | Operations Safety Analyses |
| CDR | systems and subsystem certification plans and requirements (as needed); and system safety analysis with associated verifications | Certification requirements will be reviewable. |

**Table 6—CDR Success Criteria from NPR 7123.1**

| | Criteria | Evidence |
|---|---|---|
| CDR | The detailed design is expected to meet the requirements with adequate margins at an acceptable level of risk. | Products to assess this criterion include compliance matrices, drawings, requirements and specifications. |
| CDR | Interface control documents are sufficiently matured to proceed with fabrication, assembly, integration, and test, and plans are in place to manage any open items. | Interface control documents will be complete. |
| CDR | High confidence exists in the product baseline and adequate documentation exists or will exist in a timely manner to allow proceeding with fabrication, assembly, integration, and test. | Documentation needed for fabrication, assembly, integration and test will be available. See the CDR plan for the specific list. |
| CDR | The product verification and product validation requirements and plans are complete. | The V&V plan and requirements will be reviewable. A separate review specifically for assessing verifications will be conducted after CDR. |
| CDR | The testing approach is comprehensive, and the planning for system assembly, integration, test, and launch site and mission operations is sufficient to progress into the next phase. | Documentation will be available to assess the testing approach. |
| CDR | Adequate technical and programmatic margins and resources exist to complete the development within budget, schedule, and risk constraints. | System Performance Report |
| CDR | Risks to mission success are understood and credibly assessed, and plans and resources exist to effectively manage them | The project level risks, SE&I, Software, MO, S&MA and Payload Risks will be documented. The project's risk process will be described. |
| CDR | S&MA (e.g., safety, reliability, maintainability, quality, and EEE parts) have been adequately addressed in system and operational designs, and any applicable S&MA products (e.g., PRA, system safety analysis and failure modes and effects analysis) have been approved | FMEA, Reliability Analysis |

**Table 7—SIR ERB Entrance Criteria from NPR 7123.1**

| | | |
|---|---|---|
| SIR | Integration plans and procedures have been completed and approved. | An Assembly and Integration plan will be complete. Test plans and test procedures will be complete. |
| SIR | Segments and/or components are available for integration. | Components must be available to integrate. |
| SIR | Mechanical and electrical interfaces have been verified against the interface control documentation. | Interfaces will have been verified. |
| SIR | All applicable functional, unit-level, subsystem, and qualification testing has been conducted successfully. | All applicable testing on units will have been completed before it is integrated. |
| SIR | Integration plans and procedures have been completed and approved. | Integration plans and procedures will be reviewed. |
| SIR | Integration facilities, including clean rooms, ground support equipment, handling fixtures, overhead cranes, and electrical test equipment, are ready and available. | Applicable facilities will be available. |
| SIR | Support personnel have been adequately trained. | Personnel will have been trained. |
| SIR | Handling and safety requirements have been documented. | Handling and safety documentation is complete. |
| SIR | All known system discrepancies have been identified and disposed in accordance with an agreed-upon plan. | Discrepancies will be identified and disposed. |
| SIR | All previous design review success criteria and key issues have been satisfied in accordance with an agreed-upon plan. | Previous reviews are complete. |
| SIR | The quality control organization is ready to support the integration effort | Quality assurance personnel will be assigned to the project. |

**Table 8—SIR ERB Success Criteria from NPR 7123.1**

| | Success Criteria | Project Expectations |
|---|---|---|
| SIR | Adequate integration plans and procedures are completed and approved for the system to be integrated. | An Assembly and Integration plan will be complete. Test plans and test procedures will be complete. |
| SIR | Previous component, subsystem, and system test results form a satisfactory basis for proceeding to integration. | All applicable testing on units will have been completed with acceptable results before it is integrated. |
| SIR | Risk level is identified and accepted by program/project leadership, as required. | The project continuously updates risks. The risks associated with integration will be documented. |
| SIR | The integration procedures and work flow have been clearly defined and documented. | Integration procedures will be complete and signed. |
| SIR | The review of the integration plans, as well as the procedures, environment, and configuration of the items to be integrated, provides a reasonable expectation that the integration will proceed successfully. | Assembly and Integration Plan |
| SIR | Integration personnel have received appropriate training in the integration and safety procedures | Personnel will have been trained. |

**Table 9—TRR Entrance Criteria from NPR 7123.1**

| | | |
|---|---|---|
| TRR | The objectives of the testing have been clearly defined and documented, and all of the test plans, procedures, environment, and configuration of the test item(s) support those objectives. | The testing objectives will have been clearly defined and documented, and all of the test plans and procedures are complete. |
| TRR | Configuration of the system under test has been defined and agreed to. All interfaces have been placed under configuration management or have been defined in accordance with an agreed to plan, and a version description document has been made available to TRR participants prior to the review. | Configuration of the system under test has been defined and agreed to. All interfaces have been placed under configuration management. |
| TRR | All applicable functional, unit-level, subsystem, system, and qualification testing has been conducted successfully. | All applicable functional, unit-level, subsystem, system, and qualification testing will have been conducted successfully. |
| TRR | All TRR-specific materials, such as test plans, test cases, and procedures, have been available to all participants prior to conducting the review. | All TRR-specific materials have been available to all participants prior to conducting the review. |
| TRR | All known system discrepancies have been identified and disposed in accordance with an agreed-upon plan. | All known system discrepancies have been identified and disposed. |
| TRR | All previous design review success criteria and key issues have been satisfied in accordance with an agreed-upon plan. | All previous design success criteria and key issues have been. |
| TRR | All required test resources—people (including a designated test director), facilities, test articles, test instrumentation, and other test enabling products—have been identified and are available to support required tests. | All required test resources have been identified and are available to support required tests. |
| TRR | Roles and responsibilities of all test participants are defined and agreed to. | Roles and responsibilities of all test participants are defined and agreed to. |
| TRR | Test contingency planning has been accomplished, and all personnel have been trained | Test contingency planning has been accomplished, and all personnel have been trained |

**Table 10—TRR Success Criteria from NPR 7123.1**

| | | |
|---|---|---|
| TRR | Adequate test plans are completed and approved for the system under test. | Adequate test plans are completed and approved for the system under test. |
| TRR | Adequate identification and coordination of required test resources are completed. | Adequate identification and coordination of required test resources are completed. |
| TRR | Previous component, subsystem, and system test results form a satisfactory basis for proceeding into planned tests. | Previous component, subsystem, and system test results form a satisfactory basis for proceeding into planned tests. |
| TRR | Risk level is identified and accepted by program/competency leadership as required. | Risk level is identified and accepted by program/competency leadership as required. |
| TRR | Plans to capture any lessons learned from the test program are documented. | Plans to capture any lessons learned from the test program are documented. |
| TRR | The objectives of the testing have been clearly defined and documented, and the review of all the test plans, as well as the procedures, environment, and configuration of the test item, provide a reasonable expectation that the objectives will be met. | The objectives of the testing have been clearly defined and documented, and the review of all the test plans, as well as the procedures, environment, and configuration of the test item, provide a reasonable expectation that the objectives will be met. |
| TRR | The test cases have been reviewed and analyzed for expected results, and the results are consistent with the test plans and objectives. | The test cases have been reviewed and analyzed for expected results, and the results are consistent with the test plans and objectives. |
| TRR | Test personnel have received appropriate training in test operation and safety procedures | Test personnel have received appropriate training in test operation and safety procedures |

**Table 11—SAR Entrance Criteria from NPR 7123.1**

| | | |
|---|---|---|
| SAR | 1. A preliminary agenda has been coordinated (nominally) prior to the SAR. | A preliminary agenda will be coordinated prior to the SAR with the SRB Chair. |
| SAR | 2. The following SAR technical products have been made available to the cognizant participants prior to the review: | (Heading row) |
| SAR | a. results of the SARs conducted at the major suppliers; | Not Applicable |
| SAR | b. transition to production and/or manufacturing plan | Not Applicable |
| SAR | c. product verification results; | Verification test results will be documented. |
| SAR | d. product validation results; | Validation results will be documented. |
| SAR | e. documentation that the delivered system complies with the established acceptance criteria; | Documentation that the delivered system complies with the established acceptance criteria will be complete. |
| SAR | f. documentation that the system will perform properly in the expected operational environment; | Documentation that the system will perform properly in the expected operational environment will be complete. |
| SAR | g. technical data package updated to include all test results; | technical data package updated to include all test results; |
| SAR | h. certification package; | Certification package will be reviewed. |
| SAR | i. updated risk assessment and mitigation; | updated risk assessment and mitigation; |
| SAR | j. successfully completed previous milestone reviews; | successfully completed previous milestone reviews; |
| SAR | remaining liens or unclosed actions and plans for closure | remaining liens or unclosed actions and plans for closure |

**Table 12—ORR Entrance Criteria from NPR 7123.1**

| | | |
|---|---|---|
| ORR | All validation testing has been completed. | All validation testing has been completed. |
| ORR | Test failures and anomalies from validation testing have been resolved and the results incorporated into all supporting and enabling operational products. | Test failures and anomalies from validation testing have been resolved and the results incorporated into all supporting and enabling operational products. |
| ORR | All operational supporting and enabling products (e.g., facilities, equipment, documents, updated databases) that are necessary for the nominal and contingency operations have been tested and delivered/installed at the site(s) necessary to support operations. | All operational supporting and enabling products (e.g., facilities equipment, documents, updated databases) that are necessary for the nominal and contingency operations have been tested and delivered/installed at the site(s) necessary to support operations. |
| ORR | Operations handbook has been approved. | Operations handbook will have been approved. |
| ORR | Training has been provided to the users and operators on the correct operational procedures for the system. | Training has been provided to the users and operators. |
| ORR | Operational contingency planning has been accomplished, and all personnel have been trained. | Operational contingency planning has been accomplished, and all personnel have been trained. |

**Table 13—SAR Success Criteria from NPR 7123.1**

| | Criteria | Project Expectations |
|---|---|---|
| SAR | Required tests and analyses are complete and indicate that the system will perform properly in the expected operational environment. | Required tests and analyses are complete and indicate that the system will perform properly in the expected operational environment. |
| SAR | Risks are known and manageable. | Risks are known and manageable. |
| SAR | System meets the established acceptance criteria. | System meets the established acceptance criteria. |
| SAR | Required safe shipping, handling, checkout, and operational plans and procedures are complete and ready for use. | Required safe shipping, handling, checkout, and operational plans and procedures are complete and ready for use. |
| SAR | Technical data package is complete and reflects the delivered system. | Technical data package is complete and reflects the delivered system. |
| SAR | All applicable lessons learned for organizational improvement and system operations are captured | All applicable lessons learned for organizational improvement and system operations are captured |

**Table 14—ORR Success Criteria from NPR 7123.1**

| | | |
|---|---|---|
| ORR | The system, including any enabling products is determined to be ready to be placed in an operational status. | The system, including any enabling products, is determined to be ready to be placed in an operational status. |
| ORR | All applicable lessons learned for organizational improvement and systems operations have been captured. | All applicable lessons learned for organizational improvement and systems operations have been captured. |
| ORR | All waivers and anomalies have been closed. | All waivers and anomalies have been closed. |
| ORR | Systems hardware, software personnel, and procedures are in place to support operations. | Systems hardware, software personnel, and procedures are in place to support operations. |

**Table 15—ERB Post Launch Assessment Entrance Criteria from NPR 7123.1**

| | Entrance Criteria | Project Expectations |
|---|---|---|
| PLAR | The launch and early operations performance, including (when appropriate) the early propulsive maneuver results, are available. | Not Applicable |
| PLAR | The observed spacecraft and science instrument performance, including instrument calibration plans and status, are available. | The observed science instrument performance, including instrument calibration plans and status, are available. |
| PLAR | The launch vehicle performance assessment and mission implications, including launch sequence assessment, launch operations experience with lessons learned, are completed. | Not Applicable |
| PLAR | The MO and ground data system experience, including tracking and data acquisition support and spacecraft telemetry data analysis, is available. | The MO and ground data system experience, including tracking and data acquisition support and spacecraft telemetry data analysis, is available. |
| PLAR | The MO organization, including status of staffing, facilities, tools, and mission software (e.g., spacecraft analysis, and sequencing), is available. | The MO organization, including status of staffing, facilities, tools, and mission software (e.g., spacecraft analysis, and sequencing), is available. |
| PLAR | In-flight anomalies and the responsive actions taken, including any autonomous fault protection actions taken by the spacecraft or any unexplained spacecraft telemetry including alarms, are documented. | In-flight anomalies and the responsive actions taken, including any autonomous fault protection actions taken by the experiment or any unexplained experiment telemetry, are documented. |
| PLAR | The need for significant changes to procedures, interface agreements, software, and staffing has been documented. | The need for significant changes to procedures, interface agreements, software, and staffing has been documented. |
| PLAR | Documentation is updated, including any updates originating from the early operations experience. | Documentation is updated, including any updates originating from the early operations experience. |
| PLAR | Future development/test plans are developed. | Future development/test plans are developed. |

**Table 16—Post Launch Assessment ERB Success Criteria from 7123.1**

| | | |
|---|---|---|
| PLAR | The observed spacecraft and science payload performance agrees with prediction, or if not, is adequately understood so that future behavior can be predicted with confidence. | The observed science payload performance agrees with prediction, or if not, is adequately understood so that future behavior can be predicted with confidence. |
| PLAR | All anomalies have been adequately documented, and their impact on operations assessed. Further, anomalies impacting spacecraft health and safety or critical flight operations have been properly disposed. | All anomalies have been documented, and their impact on operations assessed. |
| PLAR | The MO capabilities, including staffing and plans, are adequate to accommodate the actual flight performance. | The MO capabilities, including staffing and plans, are adequate to accommodate the actual experiment performance. |
| PLAR | Liens, if any, on operations, identified as part of the ORR have been satisfactorily disposed. | Liens, if any, on operations identified as part of the previous review, have been satisfactorily disposed. |

# APPENDIX B ACRONYMS

## B.1 Scope

This appendix lists the acronyms and abbreviations used in this document.

## B.2 List of Acronyms and Abbreviations

| | |
|---|---|
| CA | Convening Authority Cooperative Agreement |
| CCB | Configuration Control Board |
| CCC | CoNNeCT Control Center |
| CDR | Critical Design Review |
| CE | Chief Engineer |
| CIL | Critical Items List |
| CM | Configuration Management |
| CoFR | Certificate of Flight Readiness |
| CoNNeCT | Communications, Navigation, and Networking re-Configurable Testbed |
| COTS | Commercial Off The Shelf |
| CPARS | Corrective and Preventive Action Reporting System |
| CRM | Continuous Risk Management |
| DDT&E | Design, Development, Test, and Evaluation |
| DGA | Designated Governing Authority |
| DLE | Discipline Lead Engineer |
| DPM | Deputy Project Manager |
| DOORS® | Dynamic Object-Oriented Requirements System |
| DR | Decommissioning Review |

| | |
|---|---|
| EEE | Electrical, Electromechanical and Electromagnetic |
| ELC | ExPRESS Logistics Carrier |
| EMC | Electromagnetic Compatibility |
| EMI | Electromagnetic Interference |
| EPA | Environmental Protection Agency |
| ERB | Engineering Review Board |
| EVM | Earned Value Management-like |
| ExPA | ExPRESS Pallet Adapter |
| FMEA | Failure Modes and Effects Analyses |
| FRAM | Flight Releasable Attachment Mechanism |
| FRR | Flight Readiness Review |
| FS&GS | Flight Systems and Ground Systems |
| FTA | Fault Tree Analyses |
| GD | General Dynamics |
| GIU | Ground Integration Unit |
| GLPR | Glenn Procedural Requirements |
| GN | Ground Network |
| GNS | Ground Network System |
| GPS | Global Positioning Satellite |
| GRC | Glenn Research Center |
| GSE | Ground Support Equipment |
| GSFC | Goddard Space Flight Center |
| HOSC | Huntsville Operations Support Center |
| HTV | Launch Vehicle |

| | |
|---|---|
| ICD | Interface Control Document |
| IMS | Integrated Master Schedule |
| ISS | International Space Station |
| IT | Information Technology |
| ITSP | Information Technology Security Plan |
| JAXA | Japanese Aerospace Exploration Agency |
| JPL | Jet Propulsion Laboratory |
| JSC | Johnson Space Center |
| KSA | Ka-band Single Access |
| KSC | Kennedy Space Center |
| LSE | Lead Systems Engineer |
| LSIE | Lead Software Integration Engineer |
| LSP | Logistics Support Plan |
| MA | Mission Assurance |
| MOE | Measure of Effectiveness |
| MOP | Measure of Performance |
| MSFC | Marshall Space Flight Center |
| MTBF | Mean Time Between Failures |
| NASA | National Aeronautics and Space Administration |
| NPG | NASA Procedures and Guidelines |
| NPR | NASA Procedural Requirement |
| OC | Operations Concept |
| Ops | Operations |
| ORR | Operational Readiness Review |

| | |
|---|---|
| OSHA | Operational Safety and Hazard Analyses |
| PFAR | Post-Flight Assessment Review |
| PDR | Preliminary Design Review |
| PHA | Preliminary Hazard Analyses |
| PIA | Payload Integration Agreement |
| PIM | Payload Integration Managers |
| PLAR | Post Launch Assessment Review |
| PM | Project Manager |
| PI | Principal Investigator |
| POIC | Payload Operations and Integration Center |
| PRR | Production Readiness Review |
| QA | Quality Assurance |
| RF | Radio Frequency |
| RM | Risk Management |
| RMP | Risk Management Plan |
| RRP | Risk Review Panel |
| S&MA | Safety and Mission Assurance |
| SAA | Systems Assurance Analyses |
| SAR | System Acceptance Review |
| SCaN | Space Communications and Navigation |
| SDR | Software Defined Radio |
| SDS | Software Development System |
| SE | Systems Engineering |
| SE&I | Systems Engineering and Integration |

| | |
|---|---|
| SEMP | Systems Engineering Management Plan |
| SFSD | Space Flight Systems Directorate |
| SIR | System Integration Review |
| SMA | S-band Multiple Access |
| S&MA | Safety and Mission Assurance |
| SOMD | Space Operations Mission Directorate |
| SRB | Standing Review Board |
| SRD | Systems Requirements Document |
| SRR | Systems Requirements Review |
| SSA | S-band Single Access |
| SSE | System Safety Engineer |
| SSP | Space Station Program |
| STRD | Science and Technology Requirements Document |
| STRS | Space Telecommunications Radio Systems |
| SWPDR | Software Preliminary Design Review |
| SWRR | Software Requirements Review |
| TBD | To Be Determined |
| TDRSS | Tracking and Data Relay Satellite System |
| TIM | Technical Interchange Meeting |
| TPM | Technical Performance Measure |
| TRR | Test Readiness Review |
| TSC | Telescience support Center |
| V&V | Verification and Validation |
| WBS | Work Breakdown Structure |